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THERMODYNAMIC DATA OF HELIUM-3

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AIR PRODUCTS AND CHEMICALS, INC.

TECHNICAL REPORT AFML-TR-67-175

OCTOBER 1967

AIR FORCE MATERIALS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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FOREWORD

This report was prepared by Air Products and Chemicals, Inc. under Contract AF 33(615)-2870. The contract was initiated under Project No. 1470, "Cryogenic Cooling Technology", Task No. 147003, "Cryogenic Fluids and Materials".

The work was administered under the direction of the Air Force Materials Laboratory, Directorate of Laboratories, Wright-Patterson Air Force Base, Ohio, with Paul W. Dimiduk, and later E. J. Rolinski as project engineer.

The final technical report supersedes all previous quarterly reports and covers all work done during the period of the contract, from May 1965 to May 1967.

The authors gratefully acknowledge the assistance they received from the following persons: Drs. C. McKinley and G. Schmauch for valuable discussions and guidance; Dr. G. Wilson, who initiated the project; Mr. J. N. Simpson for the processing and presentation of much of the data; Mr. N. Frable for his enthusiastic attention to the experimental work; Mr. H. Schneck for his fine workmanship in the construction of the apparatus; Mr. A. Robertson for assistance in the development of some of the correlations; Mr. A. Collani and his staff of illustrators; Mr. L. Claitor and the Management Information Department for their cooperation in providing the computational facilities which were used so much in the preparation of this report; and Mrs. K. David and Mrs. M. Strouse for an excellent presentation of the report.

The manuscript was released by the authors in June 1967 for publication as an AFML technical report.

This technical report has been reviewed and is approved.

Hyman Marcus

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Chemical Physics Branch
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ABSTRACT

The PVT properties, entropy, enthalpy, internal energy, thermal conductivity and viscosity of He^3 have been tabulated between 1°K and 100°K at selected pressures up to 100 atm. Measurements were made on the PVT properties and the specific heat at constant volume of gaseous He^3 from 4°K to 20°K and a modified Strobridge equation was obtained which represented the PVT data within ± 1%. Using this equation, the SVT and HVT surfaces were obtained from 4°K to 20°K. A correlation based on the quantum version of the principle of corresponding states was used to calculate the thermodynamic properties of He^3 from 20°K to 100°K. Similar correlations were developed for the viscosity and thermal conductivity of He^3 for temperatures up to 100°K. Tabulations of thermodynamic properties of He^3 along the vapor-liquid boundary and in the compressed liquid region are also included in the tables. An H-S diagram of the data with P, V, and T as parameters is included in the report.

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NOMENCLATURE

Macroscopic Quantities:

S = entropy
H = enthalpy
U = internal energy
C_V = heat capacity at constant volume
Z = compressibility
X_o = standard state of a property X where X is S, H, U, V or p.
T_o = normal boiling of a substance
μ = viscosity
μ_o = viscosity of a gas at 1 atm
$\mu - \mu_o$ = excess viscosity
K = thermal conductivity
K_o = thermal conductivity of a gas at 1 atm
$K-K_o$ = excess thermal conductivity
ρ = density in gm/cc
v = molar volume

Microscopic Quantities:

ϵ = intermolecular force constant for the Lennard Jones potential.
k = Boltzmann's constant
σ = collision diameter
N = Avogadros number
T^* = $T/(\epsilon/k)$ reduced temperature
V^* = $V/(N\sigma^3)$ reduced temperature
p^* = $p/(\epsilon/\sigma^3)$ reduced temperature

$\Lambda^* = h/\sqrt{\epsilon m \sigma^2}$ = reduced de Broglie wavelength

$\mu^* = \mu\sigma^2(m\epsilon)^{1/2}$ = reduced viscosity

$K^* = K\left(\frac{\sigma^2}{m}\right)^{1/2}\frac{m}{k}$ = reduced thermal conductivity

SECTION I

INTRODUCTION

This report, under USAF Contract AF 33(615)-2870, assembles all the data on He^3 necessary for the design of refrigeration systems which use He^3 as the working fluid. The aim was to provide tables of PVT, enthalpy, entropy, internal energy and latent heat of vaporization data accurate to ± 1% and thermal conductivity and viscosity values with an accuracy of ± 10% over the region 1°K to 100°K and 1 atm to 100 atm.

A comprehensive survey of all the data on the thermodynamic properties of He^3 that are available in the literature was made to avoid any duplication of effort. This survey is discussed in Section II and the bibliography is provided in Appendix I. The literature data available deal mainly with the liquid region (59), the vapor pressure curve (20, 31, 60-63), the latent heat of vaporization (1), the thermal conductivity and viscosity of the liquid (4, 12, 58, 61), and apart from the isotherm data of Kerr (31) and Sherman (57, 58) below 5°K there are no measurements at all for the gas phase. An experimental program was therefore undertaken to determine some of the properties of the gas phase.

Measurements of the PVT and C_V properties of gaseous He^3 were made from 4°K to 20°K. The experimental apparatus is described in Section III and the errors and results are discussed in Section IV. The data were correlated with a modified Strobridge equation which is discussed in Section V. These data were not sufficient to describe the properties of He^3 from 1°K to 100°K, therefore it was necessary to predict the properties of He^3 from 20°K to 100°K. A correlation based on the quantum version of corresponding states was developed to predict the properties of He^3 from 20°K to 100°K and was tested against the experimental data between 10°K and 20°K. A full description of the method is given in Section VI.

Information on the viscosity and thermal conductivity for He^3 is available for the liquid (4, 13, 74) but apart from the low pressure data of Misenta (46, 47) and Fokkens et al (16), there are no data for the gas phase at all. Using the same basic theory as for the correlation of the PVT data between 20°K and 100°K, correlations were developed for the viscosity and thermal conductivity of gaseous He^3 to cover most of the temperature range. These correlations could not be checked against experimental He^3 data at high pressures as none was available. The development and accuracies of these correlations are discussed fully in Section VII.

The results of the experimental work and the values predicted by the correlations were combined with the appropriate literature data to produce a set of tables of the PVT data, entropy, enthalpy, internal energy, viscosity and thermal conductivity at selected pressures and at intervals of 1°K from 1 °K to 100°K; the vapor pressure curve and the latent heat of vaporization are also included in the tables. Section VIII describes how these data were combined to produce the tables and also lists the literature sources used for the vapor pressure and latent heat of liquid He^3. The determination of the entropy, enthalpy and internal energy of He^3 between 4°K to 20°K from the experimental data is described in Section V. The tables are listed in Appendix II. An H-S diagram covering the range 1°K to 100°K was also prepared and is included in the report.

The accuracies of the various quantities are estimated in the appropriate sections. Table I summarizes the best estimates of the probable errors in the tables of the thermophysical properties over the entire range from 1°K to 100°K. It is felt that the accuracy of the data presented here is more than sufficient for all engineering purposes.

TABLE I

ESTIMATED ERRORS FOR VARIOUS PROPERTIES

Property	Temperature Range	Pressure Range	Estimated Error
ρ	1-100°K	1-100 atm	± 1%
V	1-100°K	1-100 atm	± 1%
H	1-100°K	1-100 atm	± 3-5%
S	1-100°K	1-100 atm	± 3-5%
U	1-100°K	1-100 atm	± 3-5%
K	1-100°K	1-100 atm	± 10%
μ	12-100°K	1-100 atm	± 10%
μ	1-12°K	Not Available	

SECTION II

LITERATURE SURVEY OF EXISTING HE^3 DATA

A literature search was made to obtain all existing data relating to He^3 for the following properties: PVT data, equations of state, equilibrium data, melting point, latent heat, specific heat, entropy, expansion coefficients, compression coefficients, velocity of sound, surface tension, thermal conductivity and viscosity.

The search included the following sources of information:

C. J. Gorter - "Progress in Low Temperature Physics" Volumes I, II, III and IV, 1957 - 1964.

N.B.S. Tech. Note 309 "A Bibliography of Experimental Saturation Properties of Cryogenic Fluids" - N. A. Olien and L. A. Hall, 1965.

Mound Laboratory Report - A. E. C. Research and Development Report "He^3: An Annotated Bibliography" U. S. Government Contract No. AT-33-1-Gen-53, 1964.

Chemical Abstracts, 1958 - 1966.

The bibliography is listed in Appendix I. For convenience, reference figures indicating the regions for which data are available have been prepared and are included in the appendix. The source of data for a particular region is indicated by a letter on the diagram. Such a letter identifies a reference in the table at the foot of the figure which contains the author's name, the year of publication and the number of the reference in the bibliography, also listed in Appendix I. This bibliography is not exhaustive but covers only those sources which contain useful information up to mid-1966 when the bibliography was prepared.

SECTION III

EXPERIMENTAL APPARATUS

The apparatus was designed to make PVT and C_V measurements in the region 4°K to 20°K and 1 to 200 atm. This required a cryostat and calorimeter which were able to hold steady temperatures for a period of 12 to 15 hours, a gas handling system capable of producing high pressures with the limited amount of He^3 that was available and a calibrated volume to determine the mass of gas that was admitted to the calorimeter. He^3 is very expensive so it was essential to have a recovery system for the gas used in the experiments. These apparati and the measurement of the pressure, temperature and cell volume are described in this section. The corrections to the raw data are discussed elsewhere.

1. THE GAS HANDLING SYSTEM

The gas handling system was made of steel piping and is shown schematically in Figure 1. A 20-liter vessel was used for storage of He^3 at 1 atm. To obtain high pressures in the cryostat, the He^3 was transferred from the storage vessel to a 100 cc coil in a liquid He^4 bath by diffusion through valve 6 or pumping via valves 6, 10, 31, 34, and 4. The He^4 bath could be pumped on to produce lower temperatures. On warming the coil to room temperature, a high pressure was generated which was further enhanced by the use of the volume regulators 1, 2, and 3. The compressed He^3 thus obtained could be transferred to either the half liter cylinder or to the calorimeter in the cryostat as desired.

The half liter cylinder and the lines to the transducer formed a calibrated volume which was used to determine the mass of gas admitted to the calorimeter. The half liter cylinder was maintained at constant temperature in a water bath and the lines were insulated with glass wool. Three thermocouples at different locations measured an average temperature of the lines.

To remove gas from the cell, a vacuum pump was used which was able to produce an inlet pressure of 10^{-3} mm. of Hg. when the outlet pressure was 1 atm. A cold trap was inserted to prevent any carry over of oil from the pump. Molecular sieve columns were included to remove air or other contaminant which might have entered the system. It was thought the pump oil and the pressure generators might be sources of air contamination.

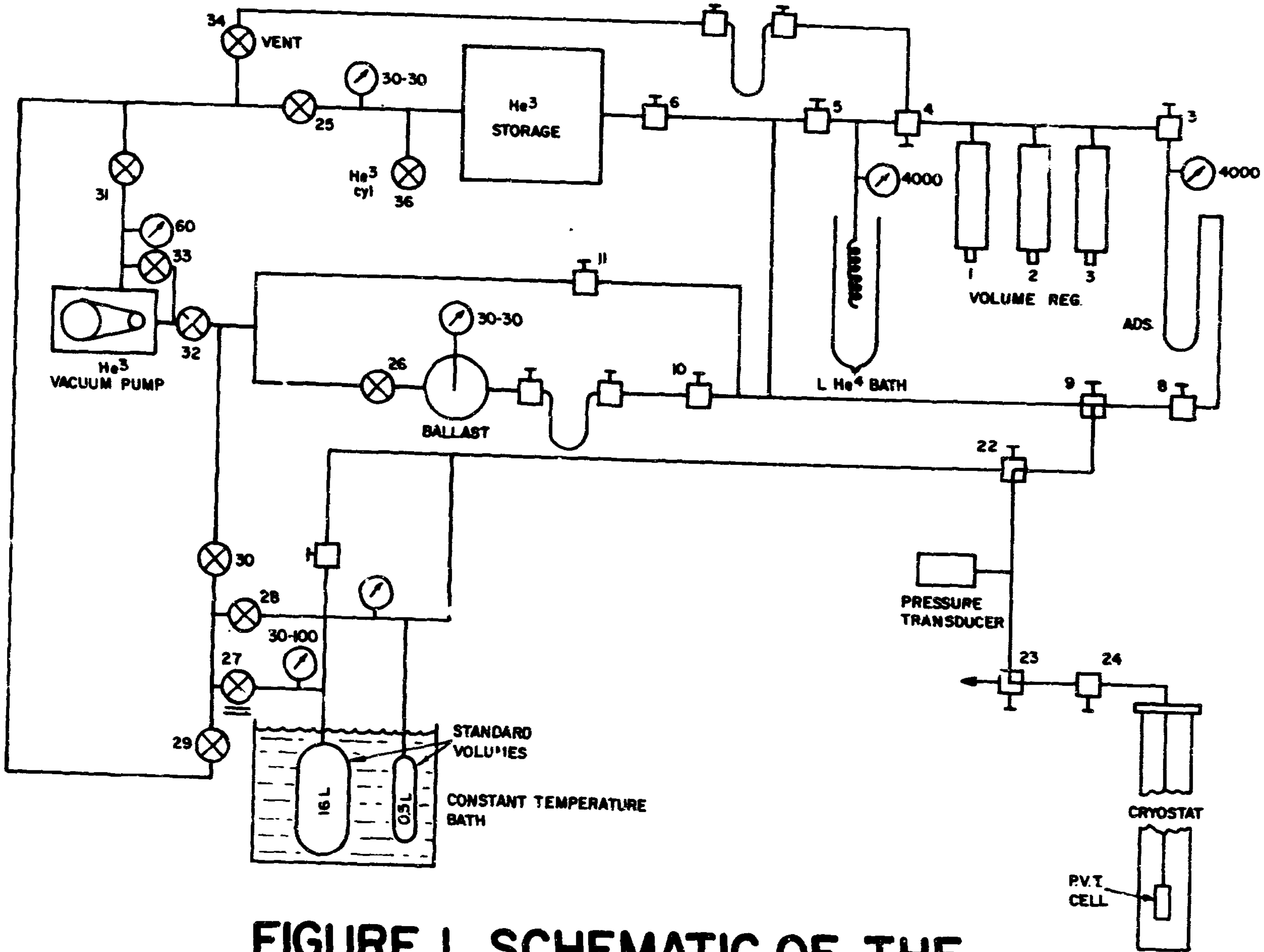

FIGURE I. SCHEMATIC OF THE GAS HANDLING SYSTEM

2. THE CRYOSTAT AND CALORIMETER ASSEMBLY

A conventional double dewar with liquid nitrogen and helium as the refrigerants was used to produce temperatures in the range 1°K to 20°K. The inner dewar containing liquid helium could be pumped on with a large pump, capacity 140 cfm, to obtain the lowest temperature, about 1.2°K. The calorimeter assemblies, shown schematically in Figures 2 and 3 for the low and high pressure calorimeters, were placed in the cryostat. The calorimeter was suspended by its fill tube in a vacuum can which isolated it thermally from the liquid helium bath. He^4 gas could be admitted to the vacuum can to link thermally the calorimeter and He^4 bath; 50 microns of He^4 gas were sufficient to ensure rapid cooling. The pieces of the can were soldered together with a solder which melts at 117°F.

The heat sink and the two copper brushes on the fill tube were designed to eliminate heat leaks to the calorimeter. The heat sink was a 700 gm. copper block with a 15 ohm heater and its temperature was always kept close to that of the cell. The copper brushes made a surface to surface contact with the steel support tube. The lower brush and heat sinks were linked directly to the He^4 bath by wires soldered to the vacuum can. All electrical connections to the calorimeter were made of 40 gauge copper wire and were varnished to the fill tube, brushes and heat sink. With this arrangement, a warm-up rate of <0.01°K/minute was obtained at 3°K.

The wide range of pressures to be covered made it necessary to construct a low pressure calorimeter and a high pressure calorimeter which are shown schematically in Figures 2 and 3.

Both calorimeters were made of copper; the low pressure cell was as light as possible to ensure that the heat capacity of the copper was much less than that of the gas at low pressures. The heat capacity of the high pressure cell was always less than that of its gaseous contents. Each calorimeter consisted of a chamber with a stainless steel fill tube silver soldered into the top and a heater made of 15 ohms of nichrome resistance wire wound around it. The heater was varnished on to the calorimeter and surrounded by a radiation shield to reduce radiation losses. The chamber was 10% filled with copper wire to ensure there was good thermal contact throughout the body of the gas so that equilibrium was quickly established. The thermometer, a doped germanium sensor, was soft soldered into a well at the top of the calorimeter.

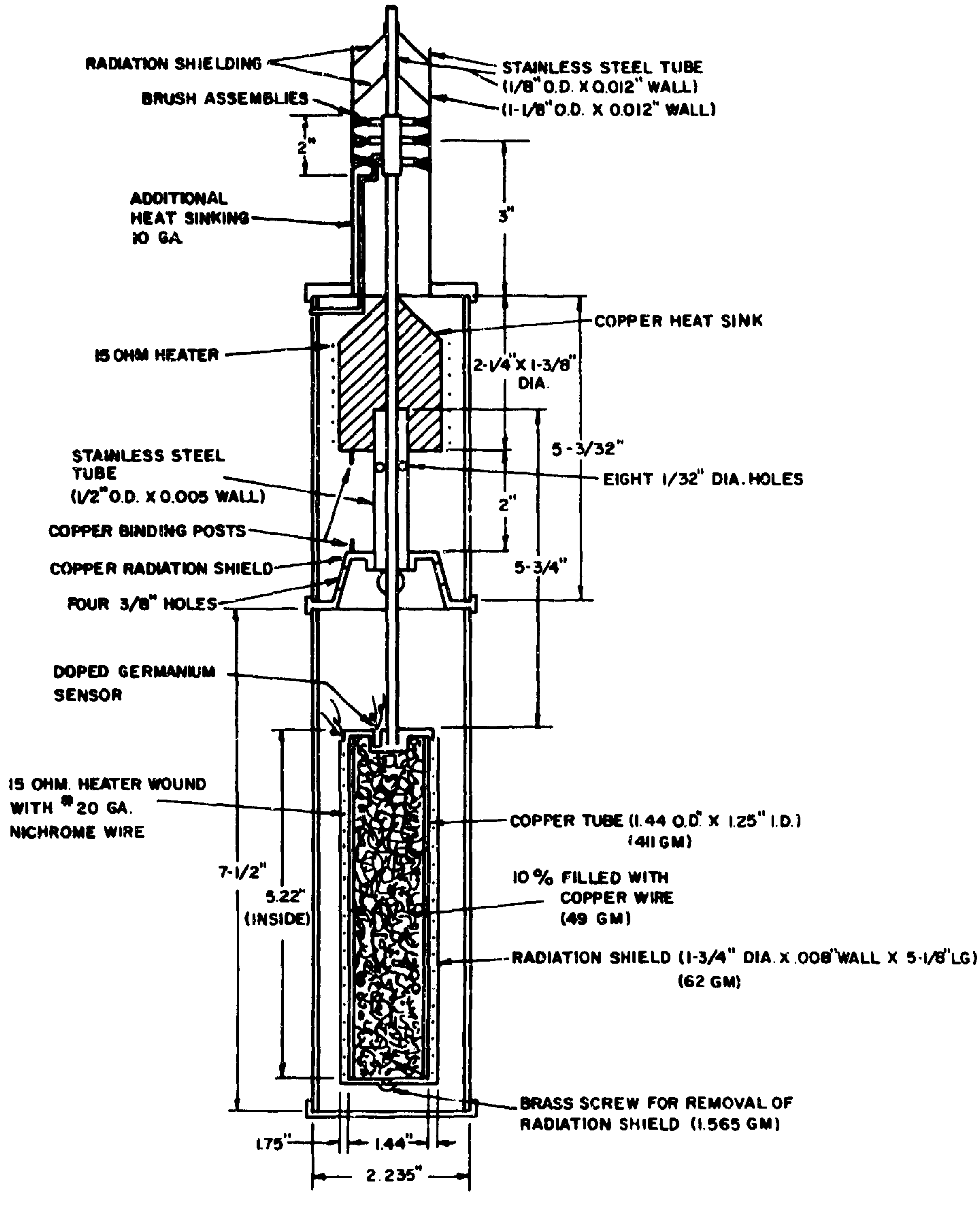

FIGURE 2. SCHEMATIC OF THE LOW PRESSURE CELL

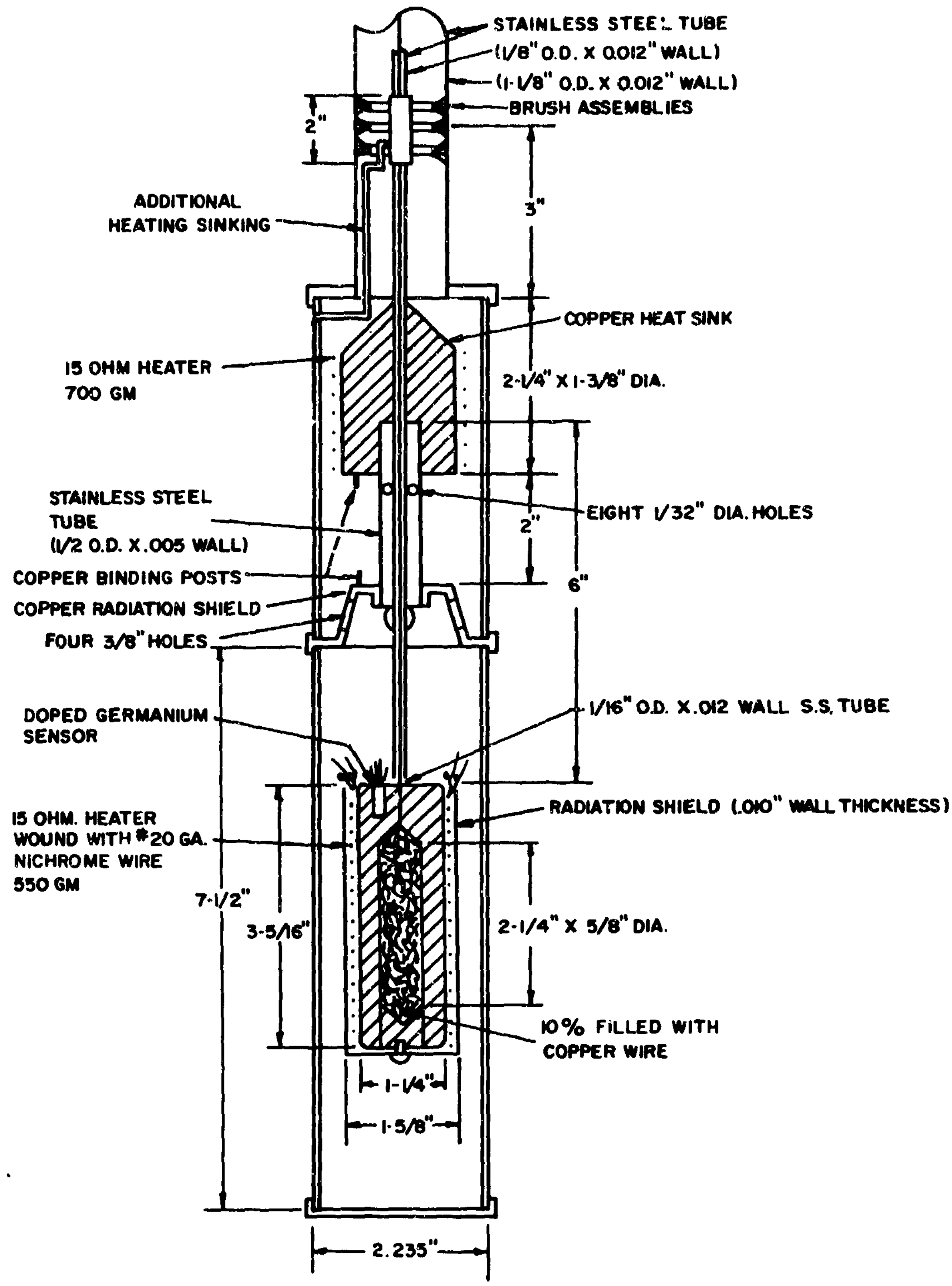

FIGURE 3. SCHEMATIC OF THE HIGH PRESSURE CELL

3. THE MEASUREMENT OF PRESSURE, VOLUME, AND TEMPERATURE

All pressure measurements were made with Dynisco model 1194H strain gauge transducers and displayed on a K-3 Leeds and Northrup potentiometer. Two transducers were used, one reading from 0 to 500 psig the other from 0 to 3000 psig. The output of the transducers at constant voltage was calibrated against a dead weight tester. The atmospheric pressure was read on a Fortin barometer as this had to be added to the transducer output to obtain the pressure. There was a slight hysteresis effect of ± 0.05% but care was taken to always measure with the pressure increasing. The outputs which were nearly linear were fitted to a cubic equation to $<$ 0.1%. The reproducibility of the output was about 0.1%.

The volume of the half liter cylinder was determined by weighing the amount of water required to fill it. The normal corrections for buoyancy, temperature, and balance sensitivity were applied and the final volume of the cylinder was taken as 433.495 ± 0.150 cc. The other volumes were found by a gas expansion method using He^4 gas with the half liter cylinder as the reference volume.

To determine the volumes of the calorimeters accurately the volume of a 75 cc. stainless steel bomb with two stainless steel valves was determined by weighing the mercury required to fill it at 1, 50, and 100 atmospheres. The volume of the bomb was (87.389 + 0.005 p) cc. where p is in atmospheres.

A valve was attached to the fill tube of the calorimeter at a point $\sim$3 cm. from the calorimeter. The bomb and calorimeter were connected and filled with Freon-14 gas at the same temperature and pressure. The ratio of the weights of Freon-14 in the two vessels determined the volume of the calorimeter. The weight of Freon in each bomb was determined to ±0.0004 gm. which enabled the volumes to be determined to ± 0.01% and the variation of volume with pressure to be followed. The final volumes for the calorimeters were:

Low pressure calorimeter 92.41 cc.

High pressure calorimeter 14.759 + 0.000096 p cc. (p in atmosphere)

The volume of the valve and tube to the cell was determined by weighing the mercury required to fill the valve and a length of tube identical to that from the valve to the cell.

A correction was made for the contraction of the copper in cooling from room temperature to 4°K; this amounted to 0.98% and was obtained from the thermal expansion data of copper (2). The variation of the cell volume with pressure was taken to be the same at all temperatures since the elastic constants vary only by $\sim$ 10% on cooling from room temperature to 4°K. The volumes of the cells were thought to be known to $\pm$ 0.1% under the operating conditions.

The temperature of the calorimeter was measured by a doped germanium sensor which was calibrated by Radiation Res., Fla. The resistance was obtained by measuring on a K-3 potentiometer the voltage drops across the sensor and a one ohm standard resistance ($1\Omega \pm 0.0001$) in the same circuit. The response of the sensor is not a linear function with temperature as may be seen from Figure 4. Difficulties were caused by this type of response when the calibration of the first sensor used was found to be in error. The change in the calibration of the germanium sensor was thought to be caused by overloading the sensor with too large a current. This was possible as an operator error could cause the pressure transducer input to flow through the sensor circuit. Small thermocouple emf's in the measuring circuit had to be eliminated as they caused complications since the error in temperature associated with the disturbance varied sharply with temperature and had a maximum in the region of $\sim$10°K. It did not prove possible to obtain an equation which fitted the calibration to 0.01°K so a cubic interpolation scheme was used which was accurate to 0.005°K (65). The output could be displayed on a recorder for ease of reading; this was not used for measurement. The temperatures of the heat sink, first and second brushes were measured by gold-silver thermocouples while the temperature of the room was measured with a chromel-alumel thermocouple.

4. THE MEASUREMENT OF THE MASS OF GAS IN THE CALORIMETER

The mass of He^3 gas in the half liter cylinder and the lines was obtained using the equation for He^4 of McCarty and Stewart (41) from the pressure, temperature and volume of the system. This equation of state has an average error of $\pm$ 0.05% at room temperature. Some of the gas was condensed into the cell and the mass remaining in the half liter cylinder, etc. was obtained. The difference between these figures gave the mass in the calorimeter fill tube and transducer manifold. A temperature distribution was assumed for the fill tube and the amount of gas in it was calculated by the equation of Mann (42) below 20°K and the

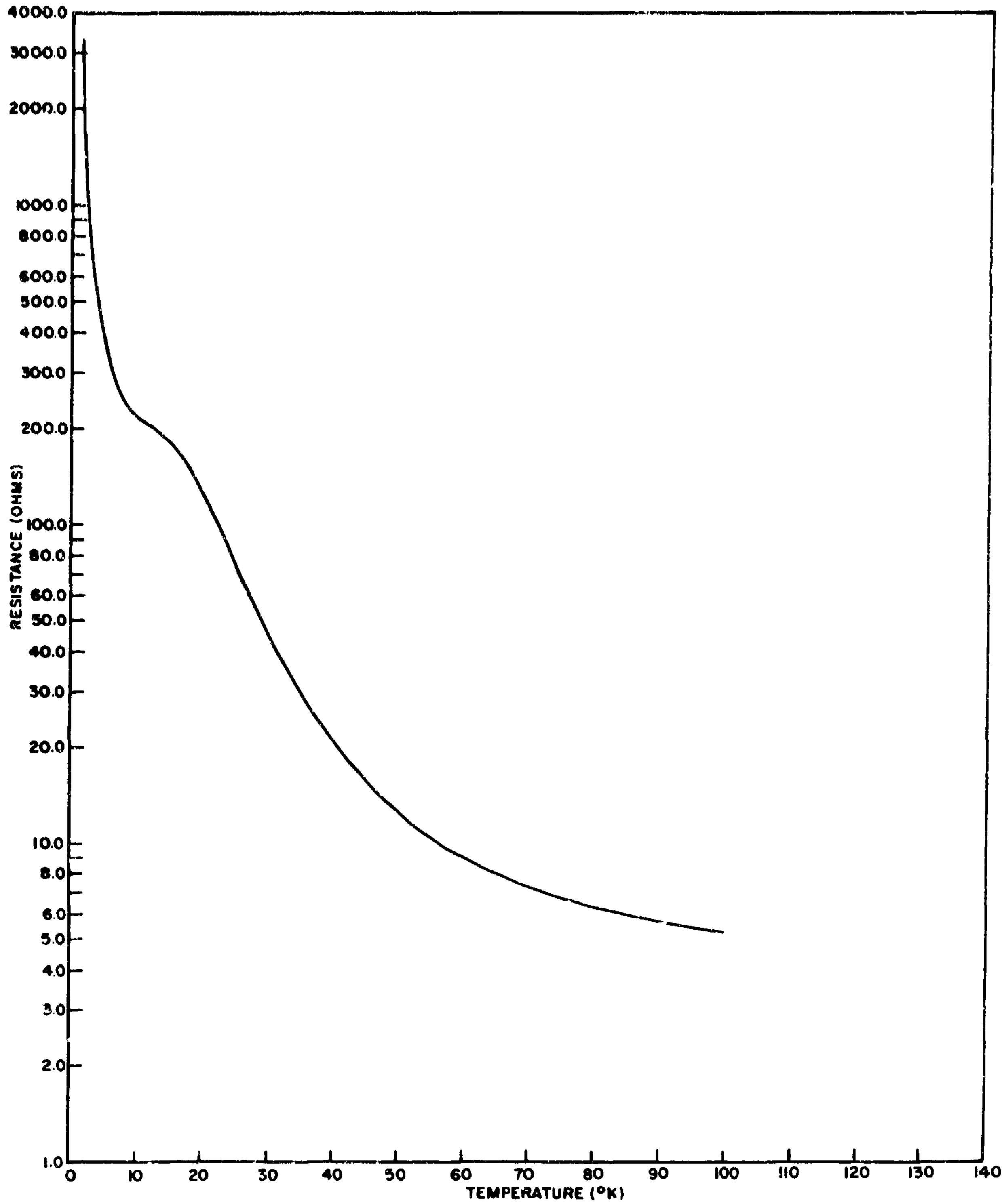

FIGURE 4. RESPONSE OF GERMANIUM SENSOR VERSUS TEMPERATURE

equation of McCarty and Stewart (41) above 20°K. The latter, while more accurate, is not valid below 20°K. At the lowest temperatures, below 7°K, the error in the correction can be as high as 10%. However since the correction was not $>$2% in this region, the overall error in the mass of gas in the calorimeter was always $<$0.2%.

5. THE ENERGY MEASUREMENTS

A power pack source using a constant voltage supply with a smooth output was used as the power supply. The output of this unit was constant to ± 0.05%. To facilitate rapid measurement during the heating period, the current and voltage across the heater could be displayed on a recorder. The measurements however, were made on a Leeds Northrup potentiometer by measuring the voltages across the heater and a standard resistance in series with the heater. The timer, which was operated by the same switch as the heater, used the main frequency as a base and could measure to 1/60 sec.

6. MATERIALS

The He^3 was supplied by Mound Laboratory, Miamisburg, Ohio with a stated purity of 99.96% He^3 ± 0.03% H_2. Before use, the gas was passed through a molecular sieve column immersed in liquid nitrogen to remove any traces of air or water which might have got into the system. After the experiments were completed the gas was reanalyzed by mass spectrometry and had essentially the same composition as before.

SECTION IV.

EXPERIMENTAL PROCEDURE, ERRORS AND RESULTS

The normal procedure was to evacuate the calorimeter, the half liter cylinder, and the lines for several days at room temperature. The calorimeter was then cooled down as far as possible with liquid nitrogen with some exchange gas in the can to make a thermal link from bath to calorimeter. Then liquid helium was put into the inner dewar to complete the cooling down to 4°K. The exchange gas was removed from the can and the calorimeter was isolated from the bath. A series of measurements was made to determine the heat capacity of the cell which was very close to that of pure copper.

A known amount of gas was admitted to the calorimeter from the half liter cylinder, after which the cylinder was isolated from the transducer and calorimeter. The pressure and temperature were then measured under stable conditions. The heater was then switched on and the heater current and voltage measured and timed. The normal temperature increment was about 1°K and the usual correction of extrapolating the fore and after temperature drifts to the midpoint of the heating period was made. This correction was always less than 0.03°K. A new constant temperature was obtained and another PVT point was measured. This sequence of measurements continued from 3°K to 20°K and was repeated with different masses of gas in the cell to cover the pressure range.

To obtain the highest pressures a different loading procedure was adopted. The gas was loaded directly into the calorimeter which was held at 1.2°K. The pressure generators were used to obtain the highest pressure possible at this temperature. The total mass of gas in the system was measured after several isopycnals had been obtained by warming the calorimeter up to the ice point and measuring the pressure of the gas in the half liter cylinder, the lines transducer manifold and the calorimeter. The mass of gas in the calorimeter was varied by releasing some gas into the half liter cylinder. The amount in the calorimeter during each isopycnal was obtained from the total amount present, minus that in the half liter cylinder. The errors associated with these experiments and the results are discussed in the following sections.

1. THE PVT MEASUREMENTS AND RESULTS

The physical measurements made for each PVT point were the temperatures of the calorimeter, brushes, heat sink, room and the pressure. In determining the molar volumes the masses of the gas in the calorimeter fill tube, transducer manifold and the cell volume are required.

The temperature was always held to better than 0.005°K and errors from this were always less than 0.1%. The pressure measurement was good to 0.1%, that is to the consistency of the calibration, and produced an error in the mass which had the same order of magnitude.

The volume of the cell was known to 0.1% but this varied somewhat with pressure. The uncertainty of the temperature gradient in the fill tube was unknown. However, examination of various temperature distributions indicated that the overall error was likely to be $< 0.5\%$ which would produce an error of $< 0.2\%$ in the calculated mass in the calorimeter. In conclusion, the total error in the PVT measurements was thought to be $\pm 0.3\%$.

The PVT data showed very little scatter and support the previous conclusion. The average scatter in the pressure and molar volume was $\pm 0.05\%$ and $\pm 0.4\%$ respectively.

Several isopycnals were made with He^4 gas to test out the apparatus. These results are shown in Figure 5b where the results of Hill and Lounasmaa (22) are also displayed. It can be seen that the agreement between the two sets of data is good, better than 0.5%. These results are an additional reason for thinking the correction for the mass of gas in the fill tube is valid.

A total of 244 points was obtained for He^3 which were smoothed graphically, and are presented in Figure 6 as a P-T diagram. At the lowest temperatures some of the corrections in the calculation of the mass in the fill tube were obtained using these He^3 results and the final results shown were obtained by successive approximations. Plots were also made of molar volume versus temperature, smoothed graphically and then cross plotted as a P versus V diagram at constant T. There was virtually no scatter in the cross plots which are shown in Figure 7 and tabulated in Table II. Values of $(\partial P/\partial T)_V$ are required in the corrections applied to C_V (see the following section) and these were taken from P-T plots at constant V, which were obtained by cross plotting the P-V diagram

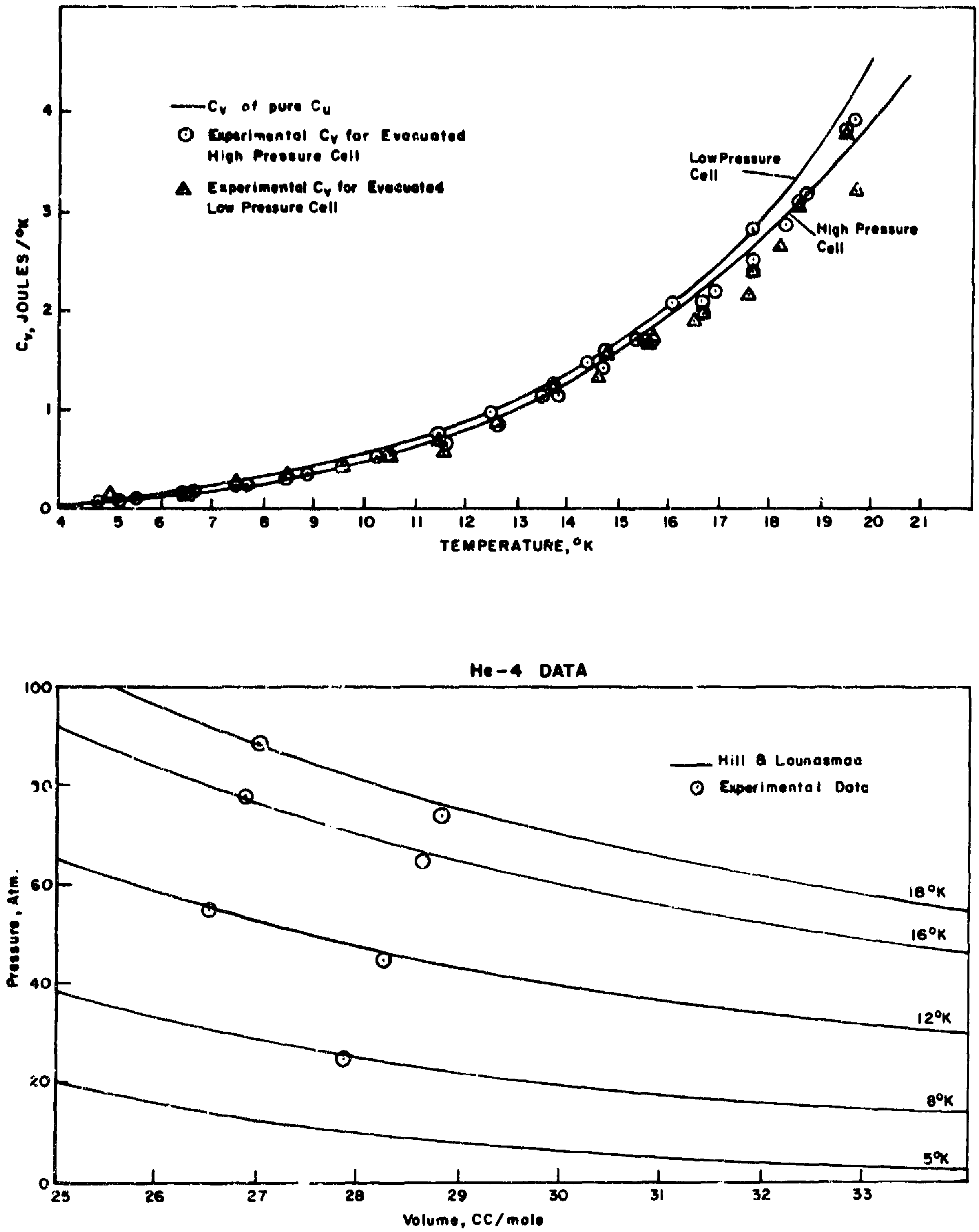

FIGURE 5. HEAT CAPACITIES OF THE CALORIMETERS

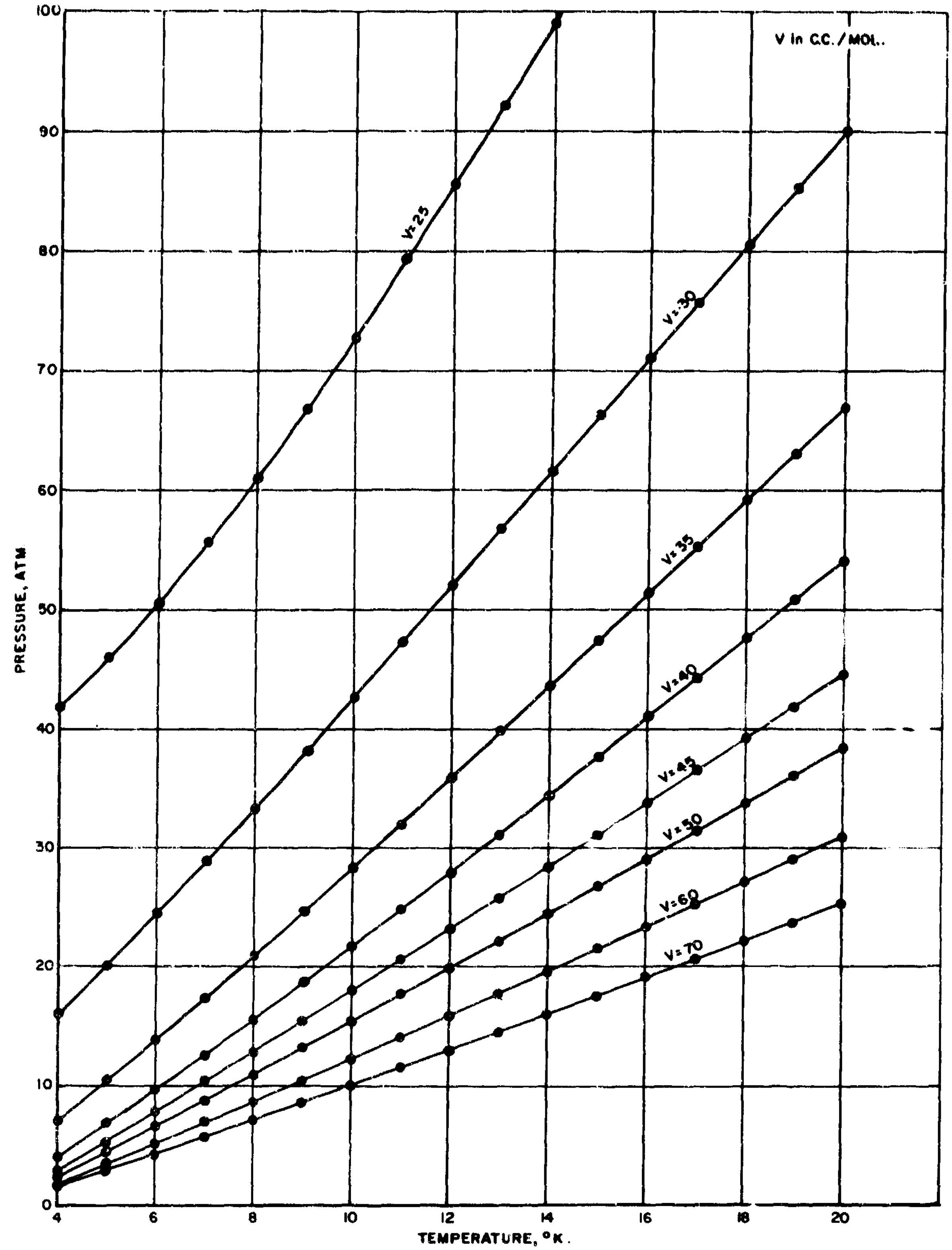

FIGURE 6. ISOPYCNALS OF PRESSURE VERSUS TEMPERATURE

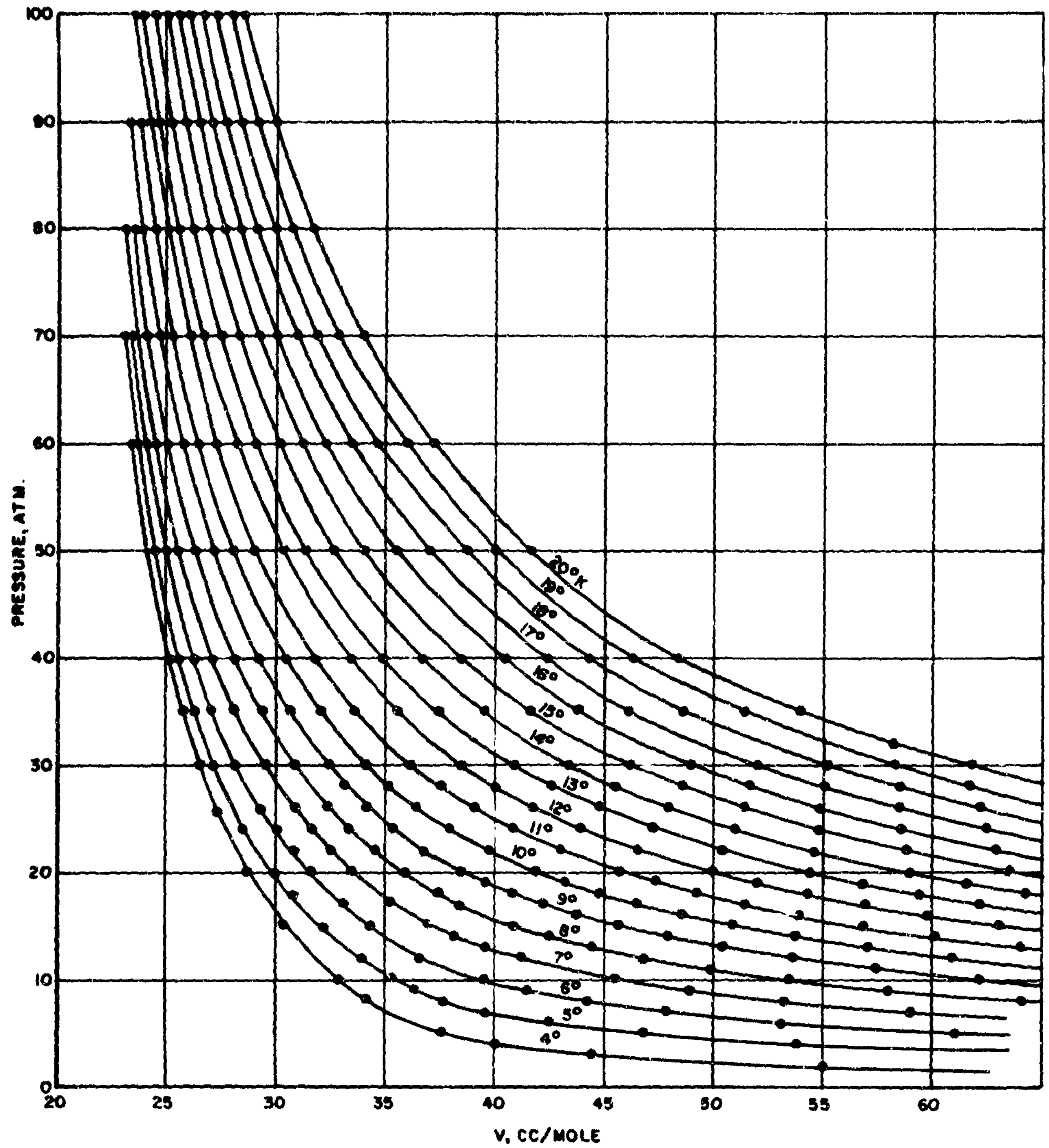

FIGURE 7. ISOTHERMS OF PRESSURE VERSUS MOLAR VOLUME

TABLE II

ISOTHERMS OF PRESSURE VERSUS MOLAR VOLUME AT TEMPERATURES BETWEEN 4°K AND 20°K FOR He^3

T, °K	P, atm 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4	00.00	55.10	44.45	40.11	37.66	36.13	35.05	34.21	33.48	32.84	32.24	31.71	31.22	30.79	30.37	30.00	29.63	29.31	28.99	28.71
5			69.80	53.83	46.84	42.52	39.70	37.72	36.40	35.40	34.68	34.04	33.44	32.89	32.37	31.87	31.42	30.97	30.53	30.09
6					61.12	53.18	47.89	44.28	41.63	39.57	37.93	36.61	35.68	34.94	34.29	33.70	33.16	32.66	32.19	31.73
7						67.70	59.05	53.25	48.93	45.68	43.22	41.26	39.64	38.22	37.03	36.04	35.25	34.60	34.01	33.50
8							71.67	64.14	58.00	53.53	49.88	46.89	44.50	42.58	40.96	39.58	38.46	37.50	36.66	35.87
9								75.15	67.88	62.14	57.40	53.68	50.47	47.93	45.71	43.85	42.27	40.87	39.68	38.62
10									76.67	70.98	65.72	61.00	57.08	53.77	50.94	48.61	46.58	44.86	43.31	41.97
11											73.01	68.37	64.06	60.13	56.87	53.96	51.45	49.28	47.40	45.77
12												74.56	70.56	66.70	63.10	59.87	56.97	54.31	52.01	49.95
13													76.00	72.22	68.70	65.34	62.20	59.46	56.88	54.54
14														77.03	73.67	70.41	67.28	64.30	61.55	59.09
15																74.99	71.96	69.04	66.25	63.57
16																	75.96	73.19	70.48	67.84
17																		76.78	74.15	71.61
18																			77.51	75.16
19																				78.12
20																				

T, °K	P, atm 22	24	26	28	30	35	40	45	50	55	60	70	80	90	100	110	120	130	140	150
4	28.19	27.72	27.31	26.93	26.57	25.82	25.20	24.67	24.21	23.80	23.41									
5	29.30	28.63	28.08	27.61	27.20	26.40	25.67	25.09	24.58	24.13	23.74	23.02								
6	30.91	30.13	29.40	28.73	28.19	27.16	26.31	25.61	25.02	24.52	24.10	23.36								
7	32.54	31.72	30.98	30.31	29.69	28.17	27.11	26.28	25.63	25.06	24.55	23.71	23.04							
8	34.53	33.39	32.43	31.61	30.89	29.50	28.27	27.22	26.32	25.65	25.09	24.20	23.48							
9	36.85	35.41	34.18	33.17	32.30	30.80	29.42	28.20	27.17	26.38	25.74	24.75	23.95	23.22						
10	39.77	37.98	36.49	35.22	34.12	32.18	30.62	29.33	28.20	27.21	26.43	25.28	24.41	23.70						
11	43.04	40.88	39.12	37.53	36.21	33.64	31.89	30.48	29.31	28.23	27.31	25.95	24.99	24.19	23.49					
12	46.58	43.93	41.79	40.12	38.53	35.54	33.44	31.77	30.42	29.30	28.30	26.65	25.53	24.67	23.95					
13	50.41	47.24	44.75	42.68	40.93	37.41	34.90	33.04	31.51	30.27	29.21	27.46	26.20	25.25	24.44	23.75				
14	54.65	50.98	47.94	45.50	43.47	39.69	36.78	34.41	32.62	31.20	30.08	28.32	26.87	25.78	24.93	24.19	23.56			
15	58.90	54.82	51.38	48.55	46.17	41.72	38.63	36.04	34.05	32.50	31.27	29.27	27.62	26.42	25.50	24.72	24.00			
16	62.88	58.66	54.91	51.61	48.87	43.95	40.54	37.74	35.47	33.75	32.36	30.14	28.36	27.06	26.04	25.19	24.47	23.81		
17	66.80	62.50	58.59	55.10	51.98	46.16	42.40	39.60	37.16	35.08	33.44	31.06	29.21	27.78	26.62	25.70	24.94	24.27	23.67	
18	70.57	66.25	62.20	58.54	55.25	48.56	44.29	41.32	38.81	36.59	34.71	31.97	30.04	28.48	27.21	26.21	25.41	24.71	24.08	
19	73.77	69.57	65.55	61.76	58.38	51.37	46.37	43.00	40.40	38.13	36.10	32.94	30.88	29.27	27.89	26.80	25.93	25.18	24.48	
20	76.76	72.73	68.82	65.02	61.47	54.00	48.44	44.71	41.88	39.60	37.50	33.99	31.63	29.92	28.55	27.34	26.42	25.60	24.89	

and are shown in Figure 6; the data are listed in Table III. Some of the plots $(\partial P/\partial T)_V$ against volume are shown in Figure 8 and the data are listed in Table IV. Since the P-T plots are almost linear, one can write $(\partial P/\partial T)_V = (\Delta P/\Delta T)_V$ and the derivative could be determined to $\pm$ 5% at all but the lowest temperatures where there was some curvature. The P-T data which have been discussed here are used in Section V as the basis for an equation of state between 4° and 20°K for He^3 and any further treatment of the data is most conveniently discussed there.

2. THE MEASUREMENT OF THE SPECIFIC HEAT, ERRORS AND RESULTS

The physical measurements made to determine the specific heat of the gas at constant volume were the heat capacity of the calorimeter, the temperatures before and after the heating period and the mass of gas in the cell, which was calculated in the same way as for the PVT data. There was the additional complication that some gas was expelled from the cell during the heating period and a correction was necessary to account for this. The cell volume varied with pressure slightly and this introduced a further correction. The total sum of these corrections amounts to $\sim$ 5% approximately.

The errors in the physical measurements of pressure and volume have been discussed previously. The temperature increment involved a small difference and was not known to better than 0.01°K which produces an error of $\pm$ 1%. The energy input was known to $\pm$ 0.1% as already noted in the discussion on the energy measurement. The heat capacity of each calorimeter was determined by several experiments with the calorimeter evacuated. The results of these experiments are shown in Figure 5 for the two calorimeters. The heat capacities of the calorimeters were very close to that of blocks of copper of the same masses as the calorimeters as may be seen from the graphs in Figure 5a where the heat capacities of copper are also shown. The scatter in the data on the heat capacity was low and the average scatter was $\pm$ 0.1 J/°K. This would introduce the same error in the heat capacity of the gas which amounted, on average, to $\pm$ 1.2%. The percentage error varied somewhat with the amount of gas in the cell.

The other errors were associated with the thermodynamic corrections necessary to obtain C_V from the measurements taken. An analysis of a system of constant volume but variable mass contained in an adiabatic calorimeter led to the following expression for the heat capacity of the gas:

TABLE III

ISOPYCNALS OF PRESSURE VS. TEMPERATURE
(P in Atm, V in cc/mole)

25 ccs.		30 ccs.		35 ccs.		40 ccs.		45 ccs.		50 ccs.		55 ccs.		60 ccs.		65 ccs.		70 ccs.		75 ccs.	
T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P
4	41.9	4	15.95	4	7.13	4	4.04	4	2.90	4	2.33	4	2.01	4	1.82	4	1.71	4	1.64	4	1.58
5	46.0	5	20.20	5	10.50	5	6.85	5	5.30	5	4.47	5	3.88	5	3.47	5	3.20	5	3.00	5	2.86
6	50.56	6	24.55	6	13.93	6	9.75	6	7.85	6	6.61	6	5.79	6	5.13	6	4.72	6	4.39	6	4.09
7	55.57	7	28.98	7	17.40	7	12.67	7	10.34	7	8.77	7	7.70	7	6.84	7	6.29	7	5.78	7	5.40
8	60.95	8	33.47	8	20.98	8	15.66	8	12.83	8	10.98	8	9.67	8	8.58	8	7.88	8	7.17	8	6.67
9	66.69	9	38.00	9	24.65	9	18.75	9	15.38	9	13.19	9	11.64	9	10.37	9	9.50	9	8.60	9	7.96
10	72.78	10	42.60	10	28.37	10	21.80	10	17.97	10	15.42	10	13.63	10	12.19	10	11.13	10	10.02	10	9.20
11	79.12	11	47.30	11	32.12	11	24.95	11	20.55	11	17.75	11	15.65	11	14.03	11	12.78	11	11.50	11	10.5
12	85.64	12	52.00	12	35.95	12	28.08	12	23.17	12	20.02	12	17.73	12	15.95	12	14.44	12	13.00	12	11.80
13	92.30	13	56.78	13	39.80	13	31.26	13	25.80	13	22.36	13	19.78	13	17.80	13	16.13	13	14.56	13	13.16
14	99.03	14	61.55	14	43.65	14	34.55	14	28.48	14	24.65	14	21.86	14	19.63	14	17.80	14	16.09	14	14.55
		15	66.25	15	47.55	15	37.78	15	31.14	15	26.95	15	23.96	15	21.50	15	19.47	15	17.64	15	15.94
		16	71.06	16	51.38	16	41.02	16	33.80	16	29.20	16	26.04	16	23.38	16	21.18	16	19.18	16	17.50
		17	75.85	17	55.24	17	44.30	17	36.46	17	31.54	17	28.12	17	25.25	17	22.85	17	20.73	17	18.65
		18	80.59	18	59.12	18	47.55	18	39.17	18	33.80	18	30.17	18	27.15	18	24.57	18	22.25	18	10.03
		19	85.30	19	63.00	19	50.85	19	41.88	19	36.14	19	32.25	19	29.03	19	26.28	19	23.81	19	21.40
		20	90.06	20	66.90	20	54.10	20	44.56	20	38.38	20	34.33	20	30.87	20	28.00	20	25.37	20	22.79

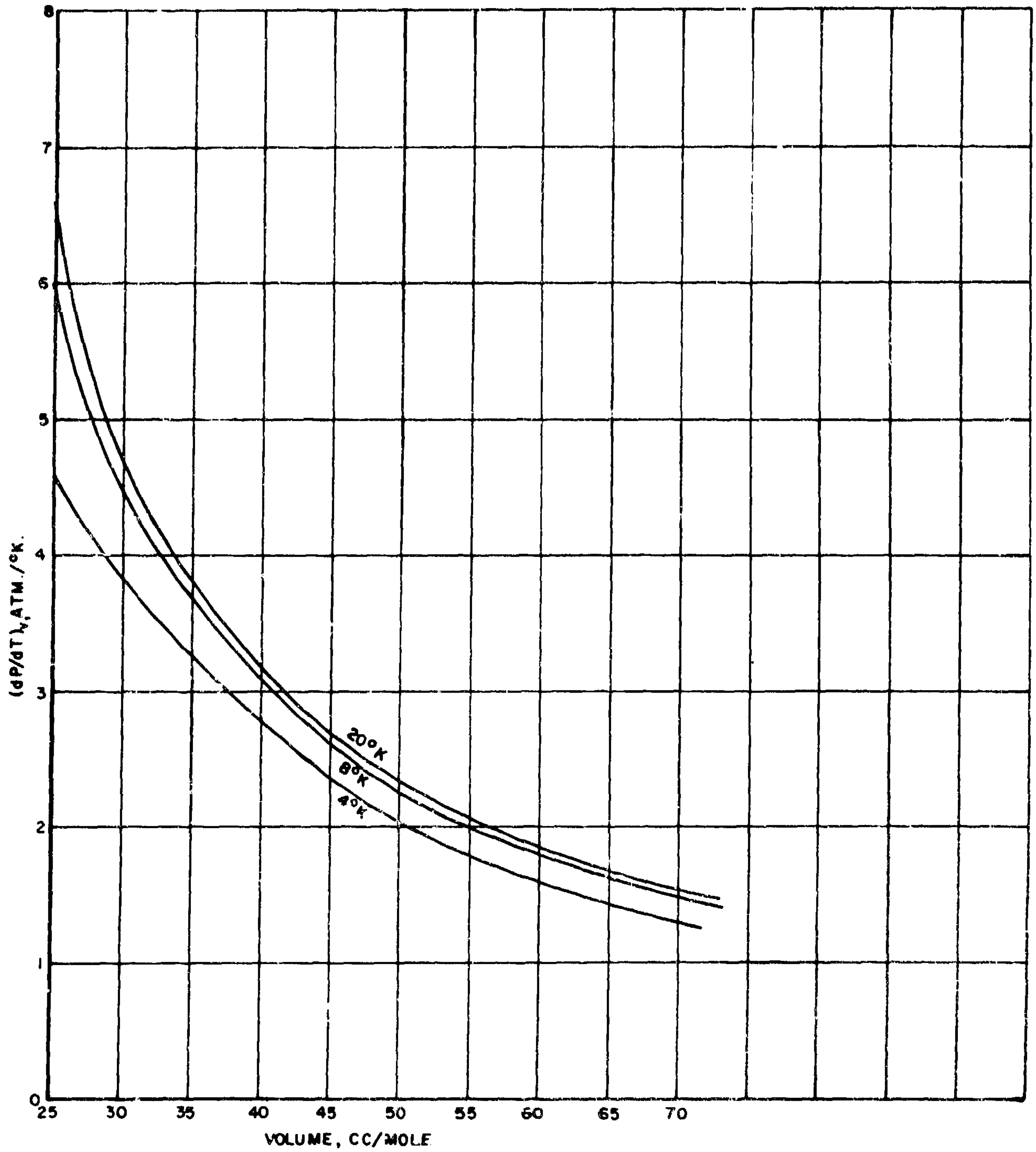

FIGURE 8. ISOPYCNALS OF $\left(\frac{\partial P}{\partial T}\right)_V$ VERSUS TEMPERATURE

TABLE IV.

VALUES OF $\left(\frac{\partial P}{\partial T}\right)_V$ AT SELECTED TEMPERATURES AND PRESSURES

T, °K	P, atm									
	25	30	35	40	45	50	55	60	65	70
4	4.38	4.05	3.20	2.78	2.38	1.98	1.80	1.56	1.42	1.31
5										
6	5.20	4.36	3.49	2.95	2.50	2.10	1.94	1.70	1.55	1.42
7										
8	5.86	4.545	3.66	3.06	2.57	2.18	2.01	1.79	1.63	1.485
9										
10	6.32	4.65	3.74	3.14	2.62	2.23	2.05	1.84	1.68	1.52
11										
12	6.55	4.715	3.80	3.19	2.65	2.265	2.06	1.86	1.695	1.54
13										
14										
15	6.57	4.74	3.87	3.255	2.685	2.29	2.07	1.865	1.71	1.54
16										
17										
18										
19										
20	6.575	4.75	3.93	3.30	2.695	2.29	2.075	1.865	1.72	1.555

$$C_V = \frac{1}{n_{av.}} \left(\frac{\Delta q}{\Delta T} - C_{cal} \right) - \frac{n_i}{n_{av}} \quad T \left(\frac{\partial P}{\partial T}\right)_V \frac{dV}{dT} \tag{1}$$

where

Δq	=	heat input
ΔT	=	corrected temperature difference
C_{cal}	=	heat capacity of the calorimeter
C_V	=	average molar heat capacity of the gas
$\frac{dV}{dT}$	=	change of molar volume with temperature
n_{av}	=	average number of moles in calorimeter
n_i	=	initial number of moles in calorimeter
$\left(\frac{\partial P}{\partial T}\right)_V$	=	change of pressure with temperature at constant volume

The last term in the expression for C_V amounts to $\sim 5\%$ of the total under experimental conditions. Since $(\partial P/\partial T)_V$ and dV/dT were both nearly linear they could be obtained accurately ($\pm$ 5%) from the data, the former from a cross plot and the latter from the experimental data. The total correction term was known to $\pm$ 10% and this introduced an error of $\pm$ 0.5% in the heat capacity data.

An additional correction for the linear variation of the cell volume with pressure was very much smaller and was assumed to be independent of temperature. The correction had the form

$$C_V = \frac{1}{n_{av}} \left[C_{uncorrected} - \left(\frac{\partial P}{\partial T}\right)_V^2 \quad \frac{dV}{dP} \right] \tag{2}$$

where

n_{av} = average number of moles in the calorimeter

$\frac{dV}{dP}$ = compressibility of the calorimeter

$\left(\frac{\partial P}{\partial T}\right)_V$ = the change of pressure with temperature of the gas at constant volume.

This correction was always less than 0.5%. The total sum of these amount to ~3%; at low pressure of gas in the cell the error tended to be larger. The results have an error of ~3% and are in accord with this estimate.

A cross plot of C_V vs. V at constant T and at constant V is shown in Figure 9 while the same data are listed in Table V. The data are seen to be quite smooth.

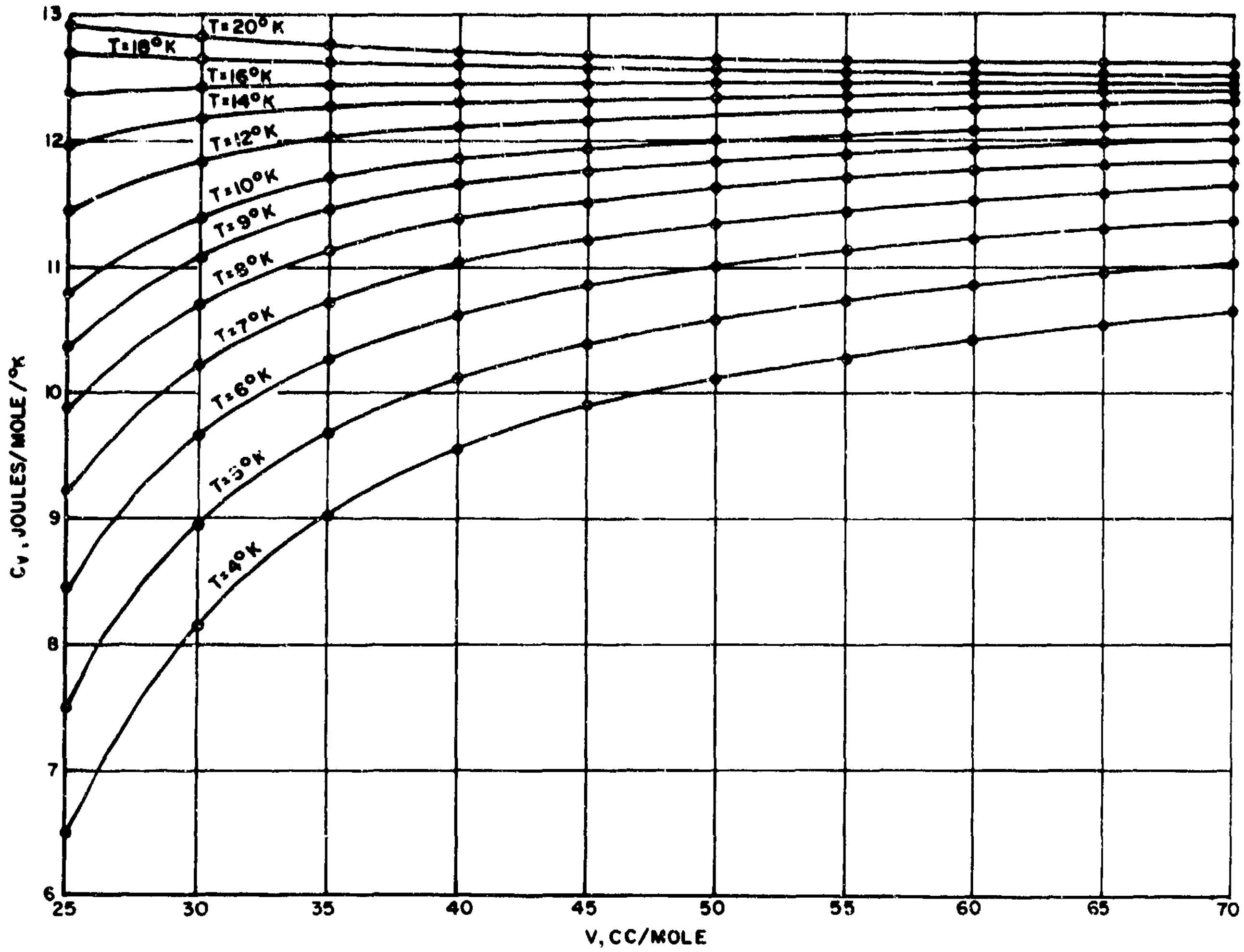

FIGURE 9. ISOTHERMS OF C_V VERSUS MOLAR VOLUME

TABLE V.

ISOTHERMS OF SPECIFIC HEAT AT CONSTANT VOLUME VERSUS VOLUME BETWEEN 4°K AND 20°K

T, °K	V, cc/mole										
	25	30	35	40	45	50	55	60	65	70	75
4	6.49	8.13	9.02	9.555	9.895	10.12	10.285	10.42	10.54	10.65	10.74
5	7.51	8.955	9.685	10.12	10.39	10.58	10.725	10.85	10.955	11.045	11.12
6	8.445	9.665	10.26	10.62	10.84	11.00	11.12	11.22	11.305	11.375	11.430
7	9.22	10.22	10.73	11.04	11.22	11.34	11.44	11.53	11.59	11.64	11.665
8	9.87	10.705	11.135	11.38	11.52	11.625	11.705	11.77	11.82	11.855	11.88
9	10.38	11.08	11.46	11.66	11.77	11.83	11.89	11.94	11.98	12.015	12.035
10	10.805	11.375	11.71	11.855	11.935	11.905	12.04	12.08	12.11	12.135	12.150
11	11.15	11.625	11.89	12.00	12.06	12.11	12.15	12.18	12.20	12.22	12.24
12	11.44	11.835	12.03	12.115	12.16	12.195	12.225	12.26	12.285	12.31	12.325
13	11.715	12.02	12.155	12.215	12.245	12.27	12.295	12.32	12.34	12.36	12.375
14	11.955	12.175	12.26	12.30	12.335	12.34	12.355	12.365	12.38	12.395	12.41
15	12.18	12.30	12.36	12.38	12.39	12.395	12.40	12.405	12.42	12.43	12.44
16	12.38	12.42	12.45	12.44	12.445	12.45	12.45	12.45	12.45	12.46	12.465
17	12.555	12.54	12.525	12.52	12.515	12.515	12.51	12.50	12.495	12.495	12.500
18	12.695	12.65	12.61	12.58	12.57	12.56	12.55	12.54	12.53	12.525	12.525
19	12.82	12.745	12.69	12.64	12.615	12.60	12.59	12.58	12.575	12.57	12.56
20	12.92	12.825	12.755	12.705	12.67	12.655	12.64	12.635	12.62	12.615	12.600

SECTION V.

CORRELATIONS OF THE PROPERTIES OF HE^3: THE EQUATION OF STATE

The experimental work described in Sections III and IV is not sufficient to describe the properties of He^3 from 1°K to 100°K and while there are other data for the liquid region (59) no data exist for temperatures higher than 20°K for any of the properties. It was necessary therefore to devise correlations which could predict the properties of He^3 at temperatures above 20°K. Also to obtain the enthalpy and entropy of He^3 from 4°K to 20°K an equation for the experimental PVT was obtained which represented the data to ± 1%.

Differences between He^3 and He^4 arise primarily from quantum effects. At higher temperatures a modified quantum version of the principle of corresponding states was used in conjunction with accurate empirical equations of state for Ne and He^4 to predict the PVT, HVT, and SVT surfaces of He^3 from 20°K to 100°K. Empirical equations were also developed for the thermal conductivity of He^4 and Ar and for the viscosity of Ar. These equations were used, together with an existing equation for the viscosity of H_2, with the quantum version of corresponding states to predict the transport properties of gaseous He^3.

Where possible, these correlations were compared with experiments. For example the PVT correlation was compared with the experimental data obtained under this program and was found to be in agreement to ± 1% between 12°K and 20°K which is highly satisfactory. Comparisons for the other correlations are much more fragmentary as there are few data available. The only comparisons possible for the thermal conductivity are with the few low pressure data of Fokkens et al (13) and the calculated values of Kerr (26) and Monchick et al (40). Agreement of ± 10% was found even at 2°K which again is satisfactory. The viscosity correlation is not valid below 12°K for He^3 but it is in agreement with the few low pressure data points of Misenta et al (37, 38) from 14°K to 20°K. The details of each correlation and the methods of developing them are discussed in the following sections.

1. THE EQUATION OF STATE

An attempt was made to find an equation for He^3 analogous to the mofified Strobridge equation which Mann and Stewart obtained for He^4 (41). The equation of Mann and Stewart was not sufficiently accurate below 10°K to be used either in the derivation of the enthalpy and entropy or for the PVT data in the critical region. It was felt, therefore, that since the critical region was the most important for design purposes, it was best to obtain a good representation of the data in this region, even if this entailed graphical smoothing of data at higher temperatures. Accordingly no attempt was made to combine the experimental data with the correlation used above 20°K (see next section) into one equation valid from 1°K to 100°K.

Data were taken from the following sources:

Sherman and Edeskuty (59) 100 points in the compressed liquid between 1° and 3.300°K.

Sherman (58) 32 points in the gaseous region from 3°K to 4°K.

Sherman (56) 6 points on the vapor liquid curve from 2.6°K to 3.324°K.

Kerr (26) 6 points on the vapor liquid curve from 1 °K to 2.8°K and 12 points in the gas phase below 5°K.

Data obtained under this contract from 4°K to 20°K; 180 points.

A total of 336 points was used initially in developing the equation.

The form of the modified Strobridge equation was:

$$T(Z-1) = \left(n_1 + \frac{n_2}{X} + \frac{n_3}{X^2} + \frac{n_4}{X^4}\right)\rho + \left(T n_5 + n_6 + \frac{n_7}{X}\right)\rho^2 + n_8\rho^3 + n_9\rho^4 + n_{10}\rho^5 + \left\{\left(\frac{n_{11}}{X^2} + \frac{n_{12}}{X^3} + \frac{n_{13}}{X^4}\right)\rho^2 + \left(\frac{n_{14}}{X^2} + \frac{n_{15}}{X^3}\right)\rho^4\right\}\exp\left(\frac{-n_{16}}{T}\right) \quad (3)$$

where $X = T + 5.6906$, ρ is the number of molecules per liter

and Z is the compressibility factor. On the vapor liquid boundary the additional restriction that the fugacity of the two phases be equal was imposed and given a weight of 3; the critical point was also weighed with a factor of 3. Limited computer storage made it impossible to obtain condition $\partial p / \partial T = 0$ at the critical point also. All other points were weighed equally.

Using a GE225 digital computer and a program, coded by Bukacek (6), a least squares fit of the data was obtained. The program was based on the Newton Raphson method of the solution of simultaneous equations. However it did not prove possible to obtain a representation of all the data with an RMS error ≤ 0.02. The gaseous data was therefore fitted by itself to equation (3). The results of the curve fitting for the gas phase above may be summarized as:

RMS error in Z-1: 0.01014

$$
\begin{aligned}
n_1 &= 0.711661079(10^{-1}) \\
n_2 &= -0.264145152(10^{1}) \\
n_3 &= 0.205080136(10^{2}) \\
n_4 &= -0.32981763\ (10^{3}) \\
n_5 &= -0.103027537(10^{-4}) \\
n_6 &= 0.123947764(10^{-2}) \\
n_7 &= -0.641439718(10^{-2}) \\
n_8 &= 0.158411494(10^{-5}) \\
n_9 &= 0.111831781(10^{-8}) \\
n_{10} &= 0.63176889\ (10^{-8}) \\
n_{11} &= -0.203977574(10^{0}) \\
n_{12} &= 0.668353927(10^{1}) \\
n_{13} &= -0.467828934(10^{2}) \\
n_{14} &= -0.89772816\ (10^{-4}) \\
n_{15} &= 0.470376428(10^{-3}) \\
n_{16} &= 0.73596\ \ \ \ (10^{-2})
\end{aligned}
$$

This compares favorably with the RMS error of the Mann and Stewart equation for He^4, though their equation extends into the liquid region whereas the present equation does not. Figure 10 shows a plot of the error in pressure vs volume for the data used in developing the curve fit. The maximum error in the pressure was 2.5% and the average error was 0.7%.

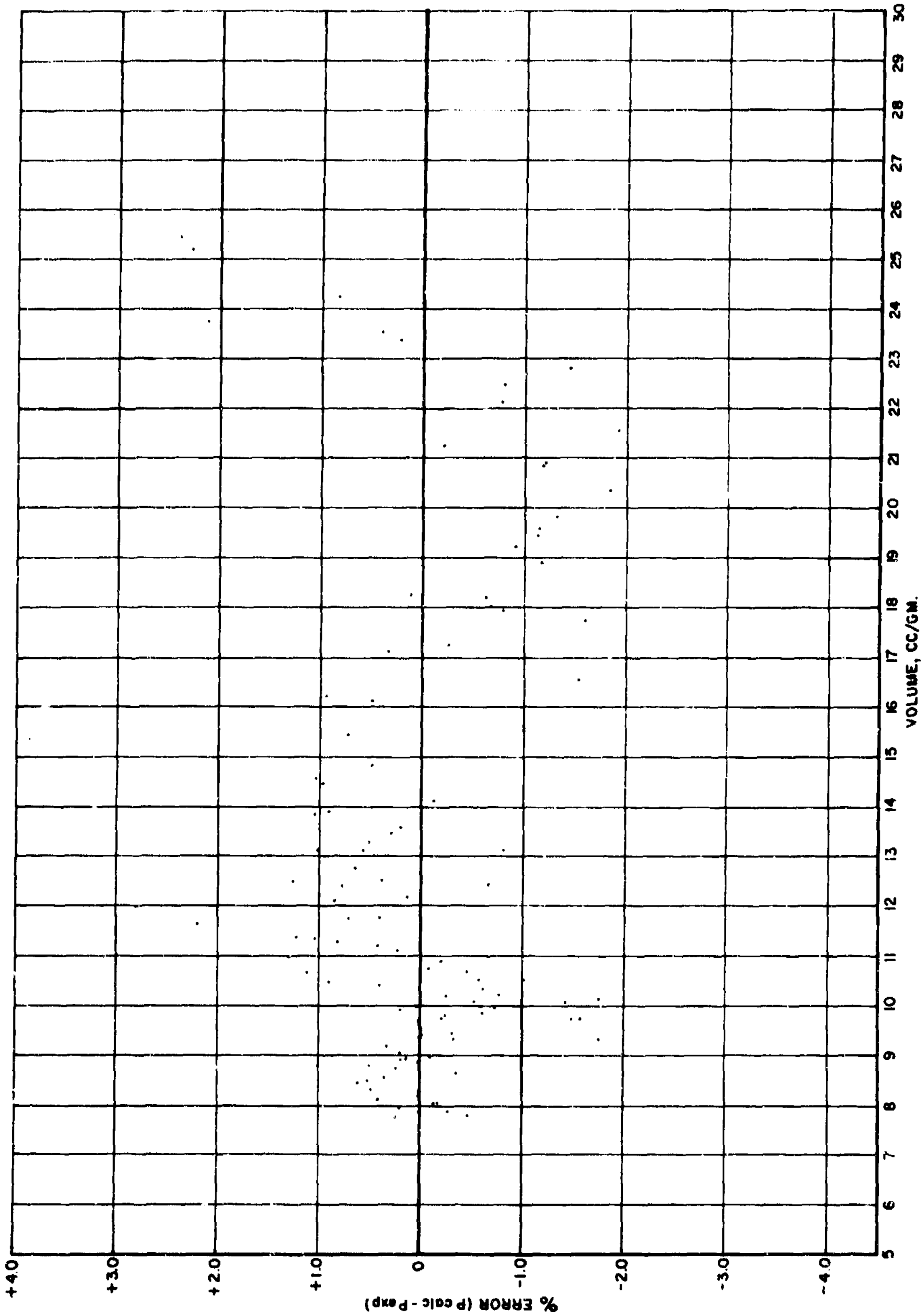

FIGURE 10. ERROR IN P PREDICTED BY EQUATION (3)

2. THE DERIVED PROPERTIES

The thermodynamic properties were derived by standard methods (24) from the PVT data by appropriate manipulation of the equation of state obtained previously. In particular:

$$S = S^{o}_{To} + C^{o}_{p} \ln (T/To) + R \ln \left(\frac{RT}{V}\right) + \int_{0}^{\rho} \left[\frac{R}{\rho} - \frac{1}{\rho^{2}} \left(\frac{\partial p}{\partial T} \right)_{\rho} \right] d\rho \quad (4)$$

$$H = H^{o}_{To} + C^{o}_{p} (T-To) + (Z-1) RT + \int_{0}^{\rho} \left\{ \frac{p}{\rho^{2}} - \frac{T}{\rho^{2}} \left(\frac{\partial p}{\partial T_{\rho}} \right) \right\} d\rho \quad (5)$$

where C^{o}_{p} is the heat capacity of an ideal gas and the reference states for S^{o}_{To}, H^{o}_{To} are for the ideal gas at 3.1905°K and 1 atm. Their values are:

To = 3.1905°K

S^{o}_{To} = 11.27754 J/g/°K

H^{o}_{To} = 22.00839 J/g

The reference state entropy includes a contribution from the nuclear spin not present in He^4 (49).

The entropy and enthalpy changes predicted by equations (4) and (5) can be tested against the enthalpy and entropy calculated from the integrations of the specific heat at constant volume. Figure 11 compares S vs V at various temperatures calculated from equation (3) with values obtained from integrations of the specific heats. A similar plot for the enthalpy is shown in Figure 12.

To bring the calculated and experimental entropy values into agreement an adjustment of .6 J/g/°K has been made to the calculated values; this adjustment does not affect the internal consistency of the calculated values. No alterations were made to the calculated enthalpy values. The agreement between the calculated and experimental enthalpies and entropies is good at all densities above 10°K,

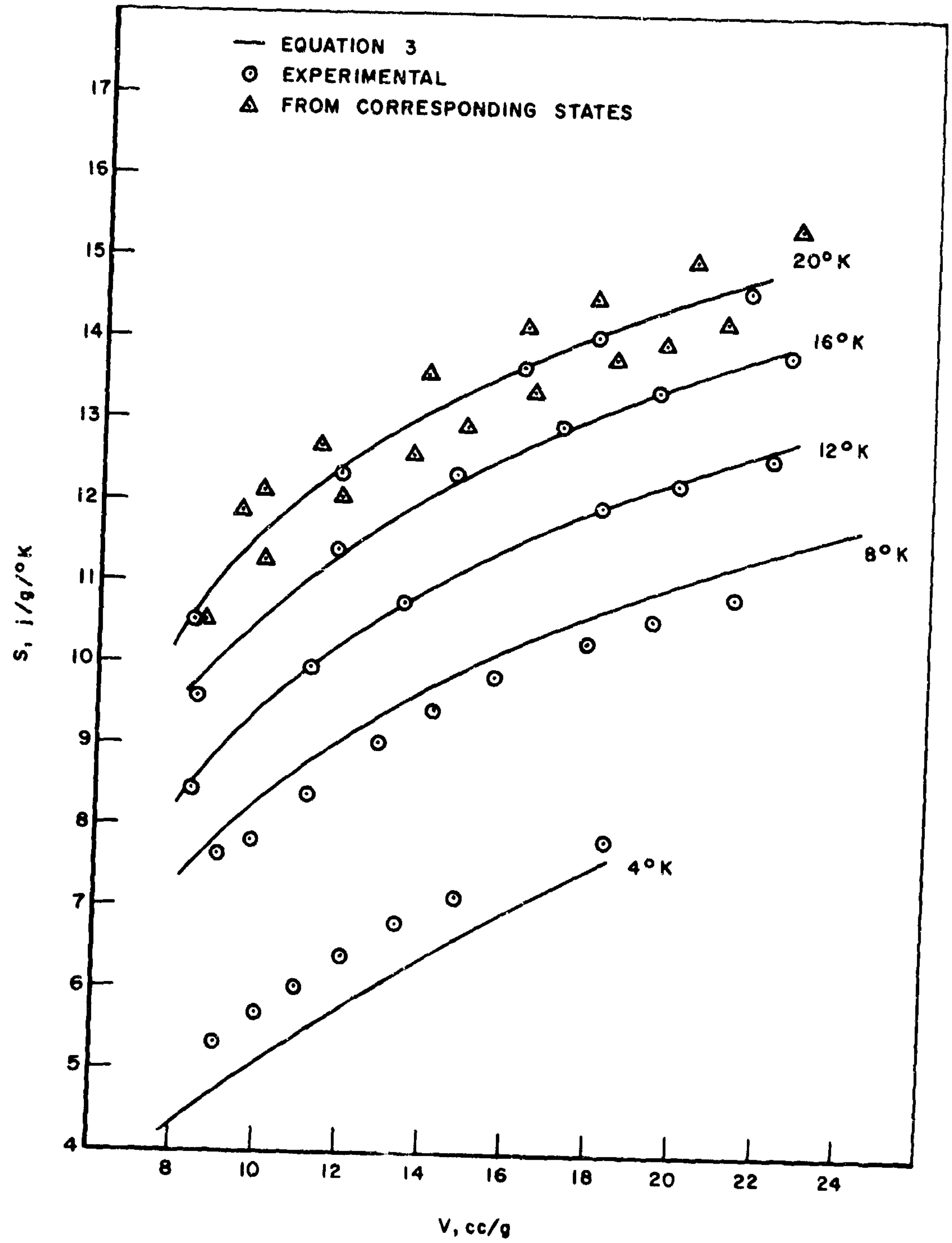

FIGURE 11.

COMPARISON OF EXPERIMENTAL AND CALCULATED ENTROPIES

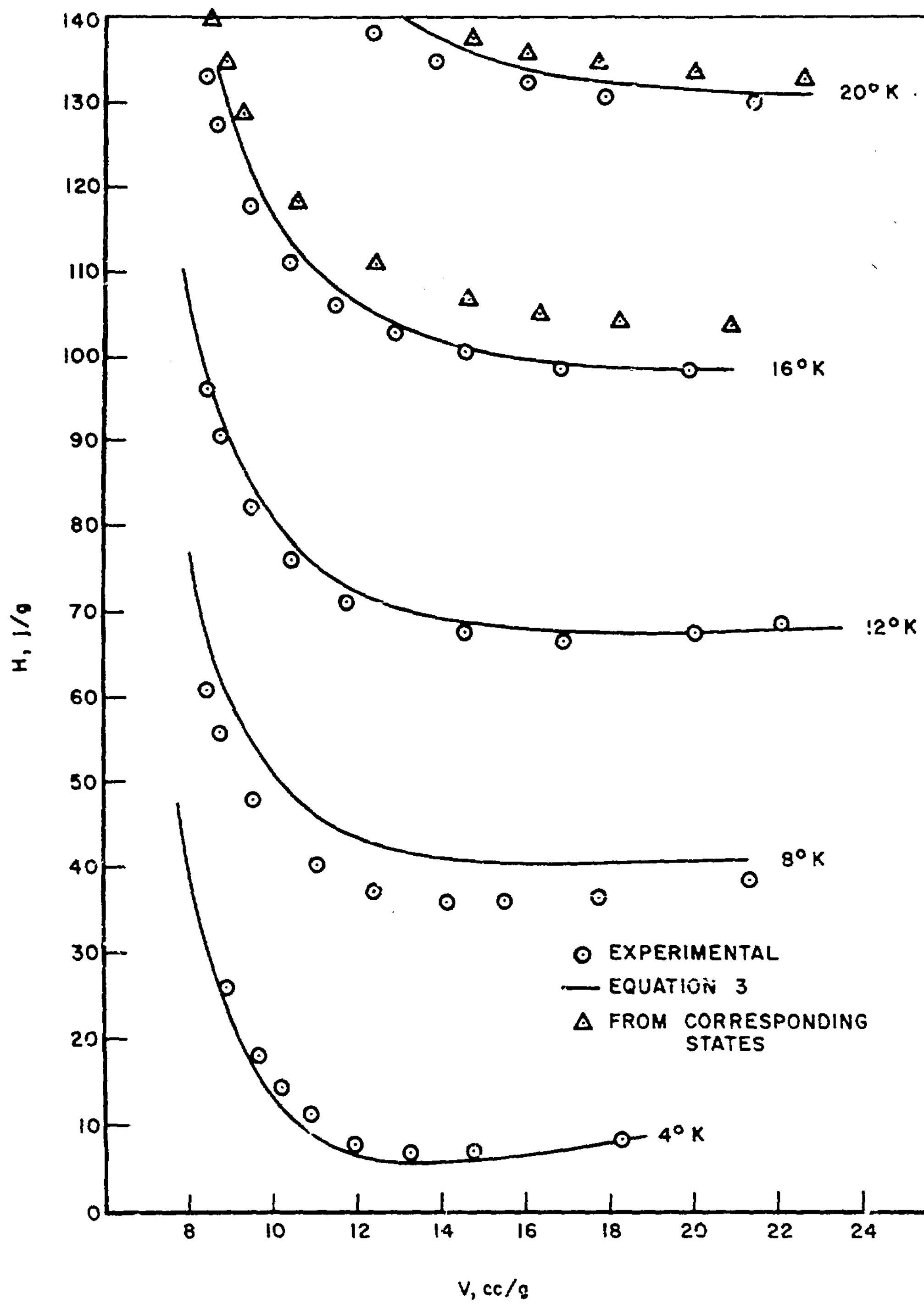

FIGURE 12.

COMPARISON OF EXPERIMENTAL AND CALCULATED ENTHALPIES

but below this temperature the predicted values of H are poor in the intermediate densities while the predicted values of S are generally too low. Also shown in Figures 11 and 12 are the predicted values of S and H obtained from the general correlation using the quantum version of corresponding states (see Section VI). These values of S and H are generally too high but are nevertheless in quite good agreement with the experimental values.

SECTION VI.

EMPIRICAL CORRELATIONS USING THE PRINCIPLE OF CORRESPONDING STATES

The original formulation of the principle of corresponding states (8-10) was in terms of the critical properties which were used to obtain the reduced values of the properties by division of an experimental property by the corresponding critical property. As originally stated, the principle said that all substances under the same reduced conditions have the same properties. This form of corresponding states works quite well for simple spherical molecules over considerable temperature and pressure ranges with the exceptions of helium, hydrogen, and to a lesser extent neon. At moderate densities and low temperatures, quantum effects can be very important for these three, the lightest of the gaseous elements. Since the critical properties are influenced by quantum effects such deviations from the principle of corresponding states cannot be interpreted easily in terms of the original formulation.

The more recent version (8) of corresponding states is based on statistical mechanics and uses the intermolecular potential constant and the molecular diameter as reduction parameters in the place of the critical properties. These parameters are obtained from second virial coefficient data or viscosity data and from the results obtained from the integrals for second virial coefficients or viscosity assuming a specific form for the intermolecular potential function. The parameters used here were derived assuming a Lennard-Jones potential which is the most commonly used form for the intermolecular function and are listed in Table VI. Though the Lennard-Jones potential is only an approximation to the true intermolecular potential, the relative sizes of the parameters do not appear to be sensitive to the specific form of the potential function.

In the molecular formulation of the principle of corresponding states, if:

(1) the intermolecular function is pairwise additive;
(2) the intermolecular interaction is spherical symmetrical; and
(3) classical statistics are obeyed

then the reduced properties of all substances are the same under identical reduced conditions. It is known that (1) is a reasonable assumption, probably good to 5% (11), while (2) and (3) are obeyed by all monatomic gases at

TABLE VI.

VALUES OF MOLECULAR AND REFERENCE
STATE CONSTANTS

1. Molecular Constants (23)

	ϵ/k	σ	P^*	V^*	Λ^{*2}
Ar	119.8	3.405	413.54	23.778	0.034969
Ne	35.6	2.749	233.40	12.5127	0.349281
He^4	10.22	2.556	83.3795	10.05796	6.9696
He^3	10.22	2.556	83.3795	10.05796	9.025
H_2	37.0	2.928	200.807	15.1196	2.9929

2. Reference State Constants

	T_o (°K)	S_o (J/g. mol./K)	H_{Ω} (J/g. mol.)
Ar	119.8	129.826	9[illegible]30.76
Ne	27.09	68.6195	1863.85
He^4	4.2144	37.0714	146.3425
H_2	20.39	80.1069	1486.50
He^3	3.1905	11.27754	22.00839

elevated temperatures. For the rare gases the principle of corresponding states is very accurate at temperatures above the critical, and can predict the pressure to within 1%. Note that strictly the molecular formulation does not include polyatomic molecules, though where a centro symmetric potential function can represent the interactions for a polyatomic molecule, the principle of corresponding states is found to be reasonably accurate. The effect of statistics on the thermodynamic functions is ignored.

The light gases, neon and He^4, show considerable deviations at low temperatures from the classical version of corresponding states and for such systems neither condition 2 nor 3 holds true. The effect of statistics is held to be small generally, for example, in the second virial coefficient for He^4 and He^3 (29), though it affects the entropy more strongly. The main quantum effect arises through the quantization of the energy levels. The natural parameter to describe this effect is the reduced de Broglie wavelength, $\Lambda^* = h/\sqrt{\epsilon m\sigma^2}$, values for which are listed in Table VI for the rare gases and hydrogen. It is through Λ^* that the differences in mass between He^4 and He^3 are introduced into the modified version of corresponding states which is used in this report. At higher temperatures these quantum effects will be reduced in magnitude, and at temperatures where the gases behave classically, they will disappear entirely.

1. QUANTUM VERSION OF THE PRINCIPLE OF CORRESPONDING STATES

The quantum version of the principle of corresponding states assumes that if:

(1) the intermolecular interactions are pairwise additive;
(2) the intermolecular interactions are centro symmetric; and
(3) the reduced properties depend on f (Λ^*) as well as the reduced conditions;

then under the same reduced conditions the reduced functions of the molecule are given by:

$$x^* = f_c\,(V^*, T^*) + f(\Lambda^*)\, f_1\,(V^* T^*) \tag{6}$$

where x^* is pressure, volume, entropy, etc.

The form of $f(\Lambda^*)$ may vary for each property and is determined empirically so as to produce a linear relationship between x^* and $f(\Lambda^*)$ suitable for extrapolation of plots of the reduced property against $f(\Lambda^*)$ for Ar, Ne, He^4, He^3, N_2 and H_2 (when such data are available)at constant T^* and V^*.

2. THE DEPENDENCE OF P^* ON Λ^*

The parameters used to obtain the reduced properties are all listed in Table VI. The basic parameters for each substance σ and ϵ were obtained from second virial coefficient data (19) assuming a Lennard-Jones potential. The three reduction parameters ϵ/σ^3, $N\sigma^3$, and ϵ/k corresponding to a fixed pressure, volume and temperature are not mutually independent and the reduced PVT surface for a given molecule does not appear to be particularly sensitive to the choice of ϵ and σ, so the errors associated with using inexact constants should not be great.

To obtain the dependence of P^* on Λ^*, plots of P^* vs $f(\Lambda^*)$ at several T^* and V^* values were made to find a form so that P^* varies linearly with $f(\Lambda^*)$.

The plot of P^* vs Λ^{*2} in Figure 13 shows P^* to vary linearly with Λ^{*2} so that approximately the equation

$$P^* = f_c(V^*, T^*) + \Lambda^{*2} f_2(V^*, T^*) \qquad (7)$$

represents the dependence of P^* on Λ^* for fixed T^* and V^*. $f_c(V^*, T^*)$ is a universal classical function and the term $\Lambda^{*2} f_2(V^*, T^*)$ represents the total quantum effects. Rigorously, the quantum effects involve a series of terms of the form $\Lambda^{*n} f_n(V^*, T^*)$ which is here approximated by $\Lambda^{*2} f_2(V^*, T^*)$. To obtain f_c and f_2 at given T^*, V^* the actual pressures of Ar or Ne and He^4 are substitued into equation 7 which can then be solved for f_c and f_2. It is possible that the differences in reduced pressures are due to other effects such as non-additivity of the molecular interactions or errors in the pressures of Ar or Ne and He^4; for convenience any differences in reduced pressures will be referred to as quantum effects though it must be borne in mind that other causes can contribute too. Naturally when quantum effects become gross, this simple representation will no longer be adequate to describe the dependence of P^* on Λ^* but the method should be of much greater accuracy than the

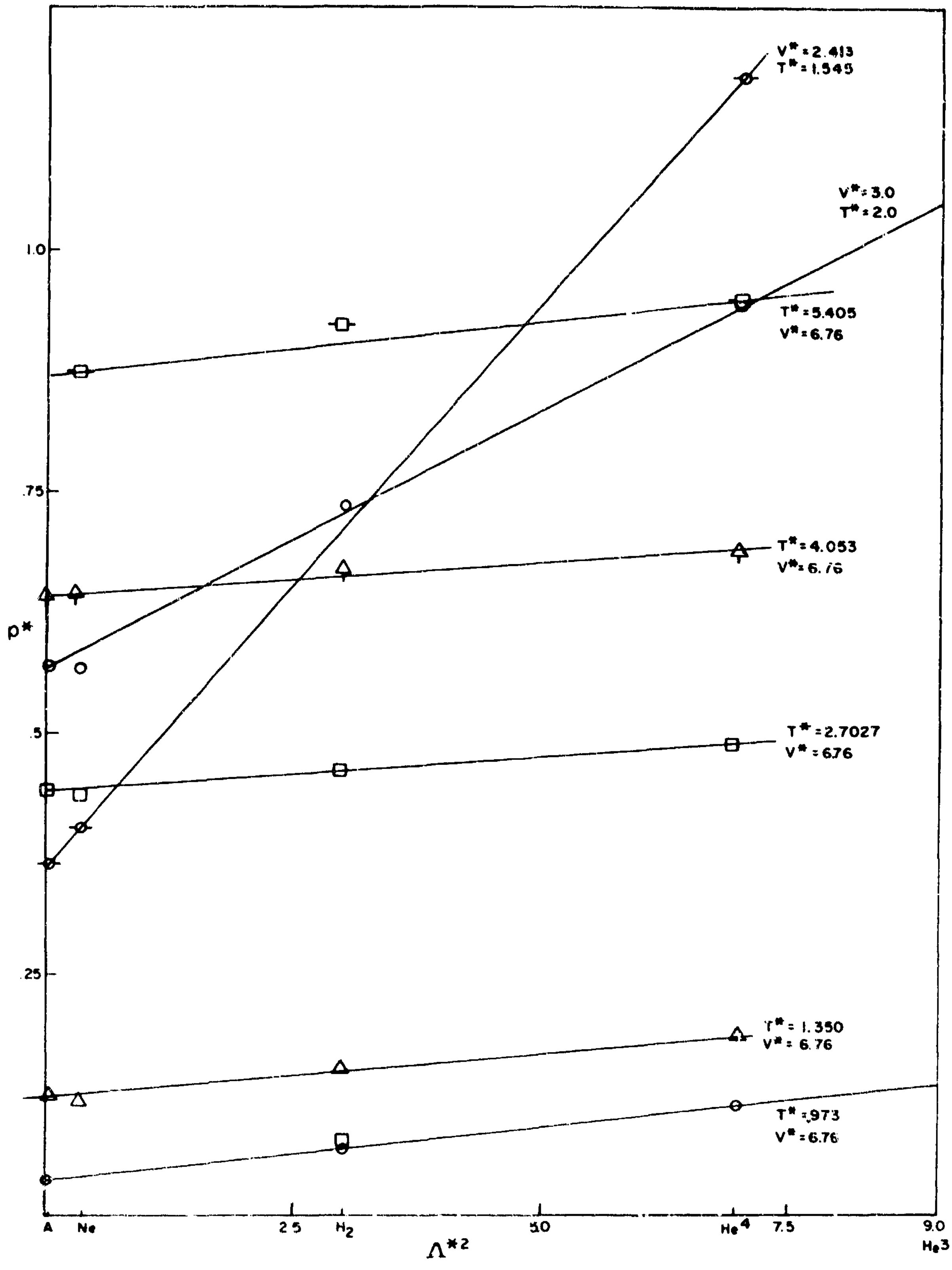

FIGURE 13. REDUCED PRESSURE VS Λ^{*2} AT FIXED (T^*, V^*)

classical form of the law of corresponding states by itself. Similar equations can be set up for any other property such as the enthalpy and entropy. A linear dependence on Λ^{*2} was found to be suitable for both entropy and enthalpy.

It remains, then, to generate the PVT surface (or SVT or HVT surface) of the substances used to determine f_1 and f_c. The modified Strobridge equations provided by the National Bureau of Standards (42, 17, 40) for He^4, Ar, and Ne are suitable since the equations represent the PVT, HVT, SVT surfaces for these molecules. These equations do have a restricted range in temperature and density for which they are applicable, but they are convenient to use in most cases. The argon equation has the smallest temperature range as it was obtained from data in which $T^* \leq 2.5$ but the neon equation is suitable for temperatures of up to $T^* \simeq 9.0$ while the helium-4 equation is valid to $T^* = 30$. Near the critical region however, the equations can be seriously in error and this results in errors in the determination of f_c and f_2. The use of these equations in conjunction with equation (7) and the reduction parameters to predict the properties of Ne, H_2, and He^3 will now be discussed. All the calculations described here were made using the equations for Ne (14) and He^4 (42), except for the prediction of the properties of Ne.

3. THE PROPERTIES OF NEON

There is only a very limited amount of PVT data available for Ne with which comparisons can be made. The data of Michels et al (45) at room temperature and above are the main source together with the recent data of Sonntag and Sullivan (64) in the region 70°K to 120°K. In addition, there is the equation of McCarty & Stewart (40) which is more comprehensive but is not based on experimental data at temperatures below 55°K since none was available when the correlation was developed. Neon is normally thought of as a gas which obeys the classical version of corresponding states closely. However, Figure 13 shows that for $V^* = 2.413$, $T^* = 1.545$ quantum effects can be as large as 10%. At low densities the influence of quantum behavior rapidly becomes very small especially at high temperatures.

Figure 14 shows an error plot for the values of P predicted by our correlation compared with the experimental results of Sonntag et al (64) at 70°K and 100°K. The average error in the predicted values of our correlation was <0.5% with a maximum of 1.95%. Also shown in Figure 14 are comparisons of the values predicted by the McCarty-Stewart equation (40) at 70°K which is more than ~1.2% too low at pressure >100 atm. The

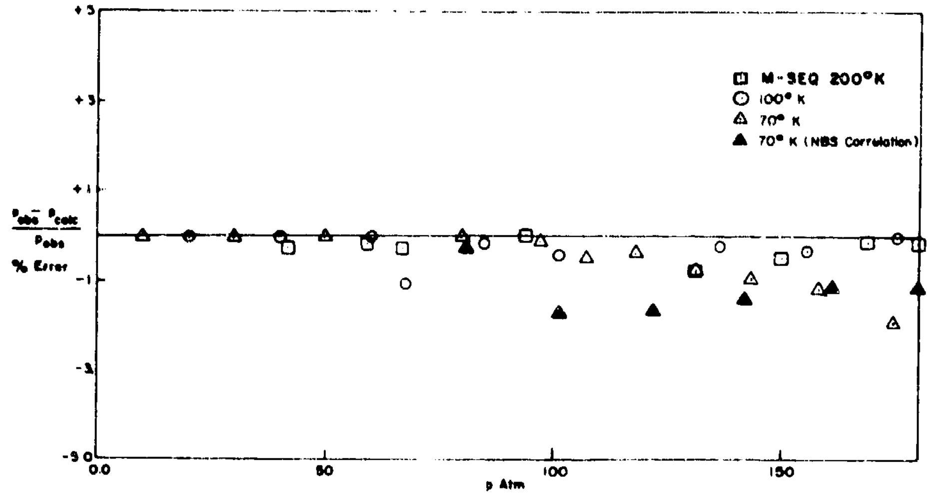

FIGURE 14a. COMPARISON OF THE PRESSURES FROM THE McCARTY STEWART EQUATION AND THE PRESENT CORRELATION WITH EXPERIMENTAL PRESSURES AT 70° K AND 100°K

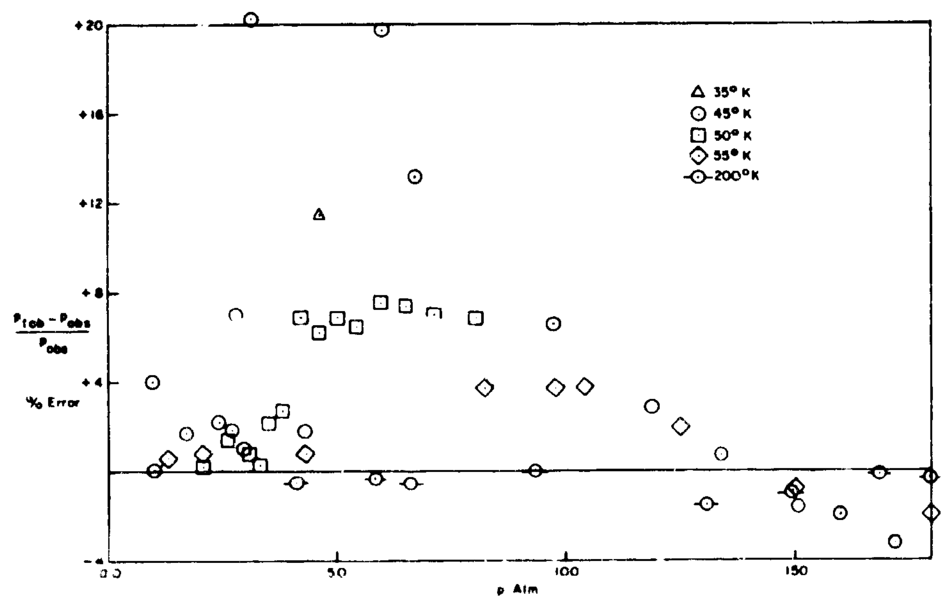

FIGURE 14b. COMPARISON OF THE PRESSURES PREDICTED BY THE PRESENT CORRELATION WITH THE McCARTY STEWART EQUATION FOR NEON

remaining plots at 35°K, 45°K, 50°K, 55°K, and 200°K are the differences between the values predicted by the McCarty-Stewart equation and the present correlation. At 200°K the average difference is <0.3% but for the three isotherms at 45°, 50°, and 55° there is an average difference of 5.9%. The largest errors in each isotherm always occur in the region near the critical point where the pressure changes very slowly with volume. The points in this region for each of the isotherms show errors of up to 25%; the isotherm at 45°K being less than 1°K from the critical temperature has the largest error. If this isotherm is excluded, the average difference between the McCarty-Stewart equation and the present correlation for the 100 points examined is 1.6%.

In examining the McCarty-Stewart equation at 70°K, it was found that this equation predicts lower reduced pressure than the argon equation at the same reduced temperature and volume. Since quantum effects always appear to produce reduced pressures larger than the classical values, the McCarty-Stewart equation would seem to be too low by ~0.5% at 70°K. At 50°K however, the McCarty-Stewart equation predicts reduced pressures greater than the corresponding reduced pressures for argon, as is normally expected.

Via standard thermodynamic arguments, as outlined by Hust and Gosman (24), the same empirical equations can be used to obtain the entropy and enthalpy for Ar and He^4. Proceeding in the same way as previously, the entropy and enthalpy of neon were obtained at 45°K, 50°K, 70°K, 100°K, and 200°K and compared with the values of entropy and enthalpy generated from the McCarty-Stewart equation. Figure 15 shows the difference between the entropies of neon calculated by the present method and by the McCarty-Stewart equation. The agreement is better than 3% at 200°K, 100°K and 70°K but at 50°K, though there is agreement up to 30 atm., above this, there are differences of up to 4%. Similar differences of up to 4% at 50°K can be observed for the enthalpy of neon which is shown in Figure 16. The discrepancies at 50°K in the values of S and H between the two correlations merely reflect the differences in the values of the pressure and temperature derivatives of the pressure in the two correlations.

In conclusion, except perhaps for the critical region, the present correlation can be used to obtain pressure data for Ne accurate to <1% and entropy and enthalpy data to about 3% also. Because of the absence of data, neon is not suitable for testing the present correlation near the critical region. However, there are data available for low temperature H_2 which can be used to test this approach in the critical region and this is discussed in the following section.

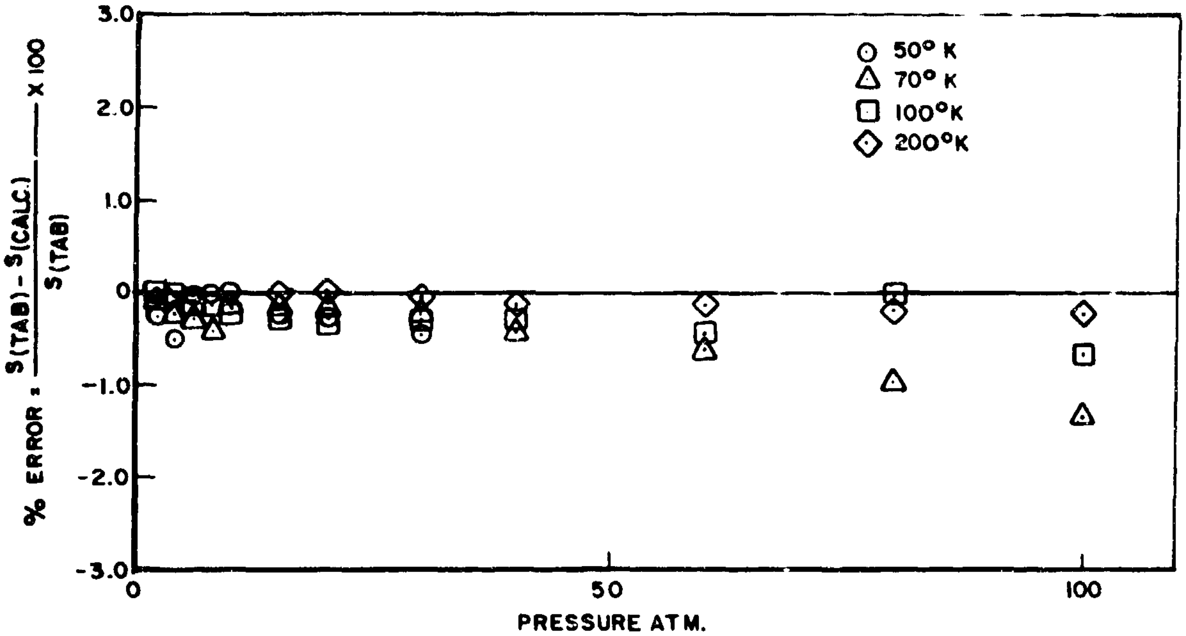

FIGURE 15. ERROR IN THE PREDICTION OF THE ENTROPY OF NEON

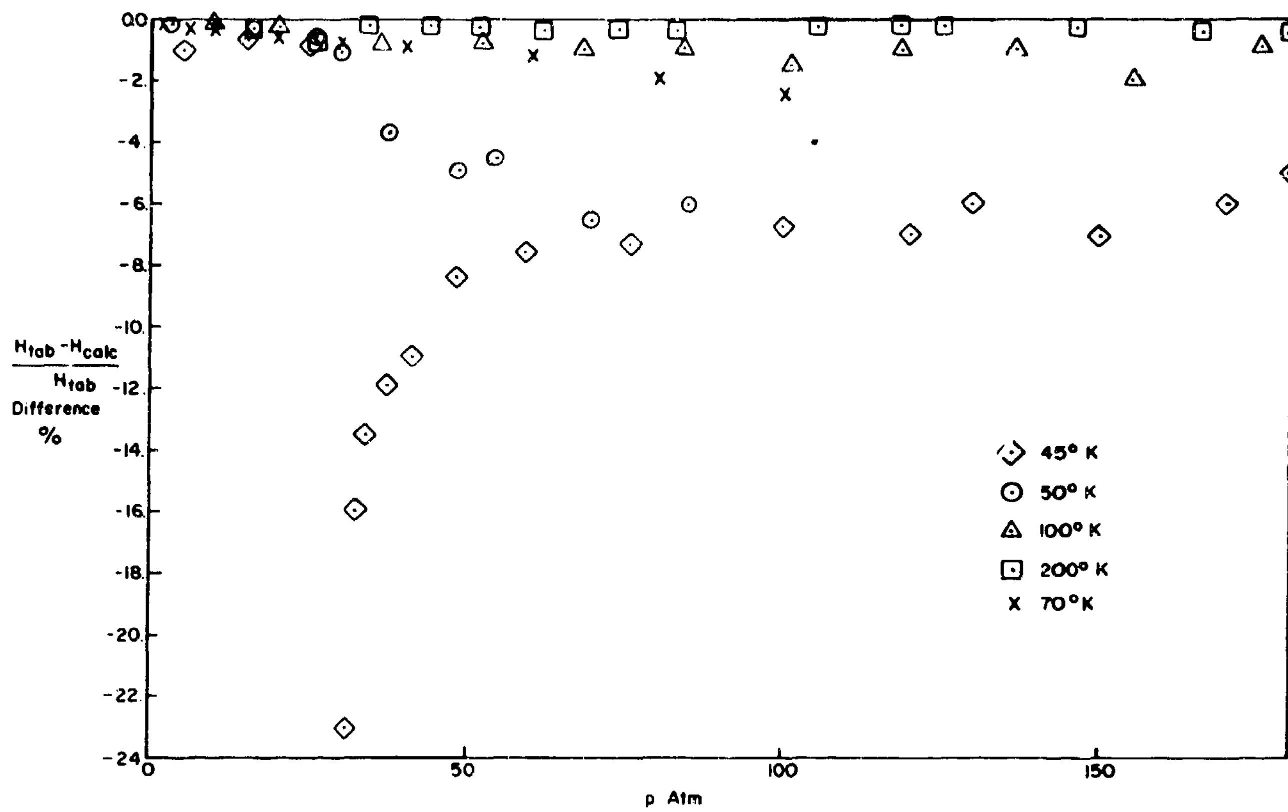

FIGURE 16. COMPARISON OF ENTHALPIES FROM THE McCARTY STEWART EQUATION AND FROM THE PRESENT CORRELATION FOR NEON

4. THE PROPERTIES OF HYDROGEN

Hydrogen is the lightest of all molecules and it is well known that it shows considerable deviations from the classical law of corresponding states. The extensive tabulations of Wooley, Scott, and Brickwedde (70) cover the entire range from 10°K to 600°K and pressures of up to 500 atm. However, there are difficulties in applying the principle of corresponding states to hydrogen. Firstly, hydrogen is not monoatomic and the Lennard-Jones potential does not describe the molecular interactions as well as for the inert gases. There are also the difficulties associated with the ortho para ratio being a function of temperature and the possible changes in the force constants resulting from this. As noted before, the effect of statistics is ignored in the formulation of corresponding states. The predictions below apply then only to normal hydrogen and no account is taken of changes in the ortho para ratio.

The differences between the values of the pressure produced by the present correlation and the experimental tabulations of Wooley et al (70) are shown in Figure 17. The high temperature isotherms 100°K and 200°K show excellent agreement but, as with neon, the region near the critical is not reproduced well by this correlation. The errors for the 36°K isotherm has a maximum error of 16% at 15.5 atm. but this is close to the critical point where large changes in the pressure occur for small changes in volume. Overall for the 150 random points computed and compared with the experimental data, the agreement was good to 3%, at temperatures above 100°K the error in the prediction of the pressure of H_2 is $<1\%$. Figure 18 shows the comparison of the enthalpy predicted by the present correlation with the data of Wooley et al (70). The agreement is seen to be good for the high temperature isotherms at 55.56°K, 77.78°K, and 100°K; but, again there is poor agreement near the critical region for the 36°K and 40°K isotherms. The average difference between the 100 computed points and the experimental data was 0.4% with a maximum error $\sim$1.0%.

5. THE PROPERTIES OF He^3

A comparison of the PVT properties for He^3 predicted by this correlation and the experimental data is made in Figure 19 which shows a comparison of the predicted values with the experimental data using Ne and He^4 equations as the basis functions. The isotherms from 12°K to 20°K show agreement with an average error of 1.5% and a maximum error of 5.0% over the pressure range covered. Below 12°K however, the disagreement

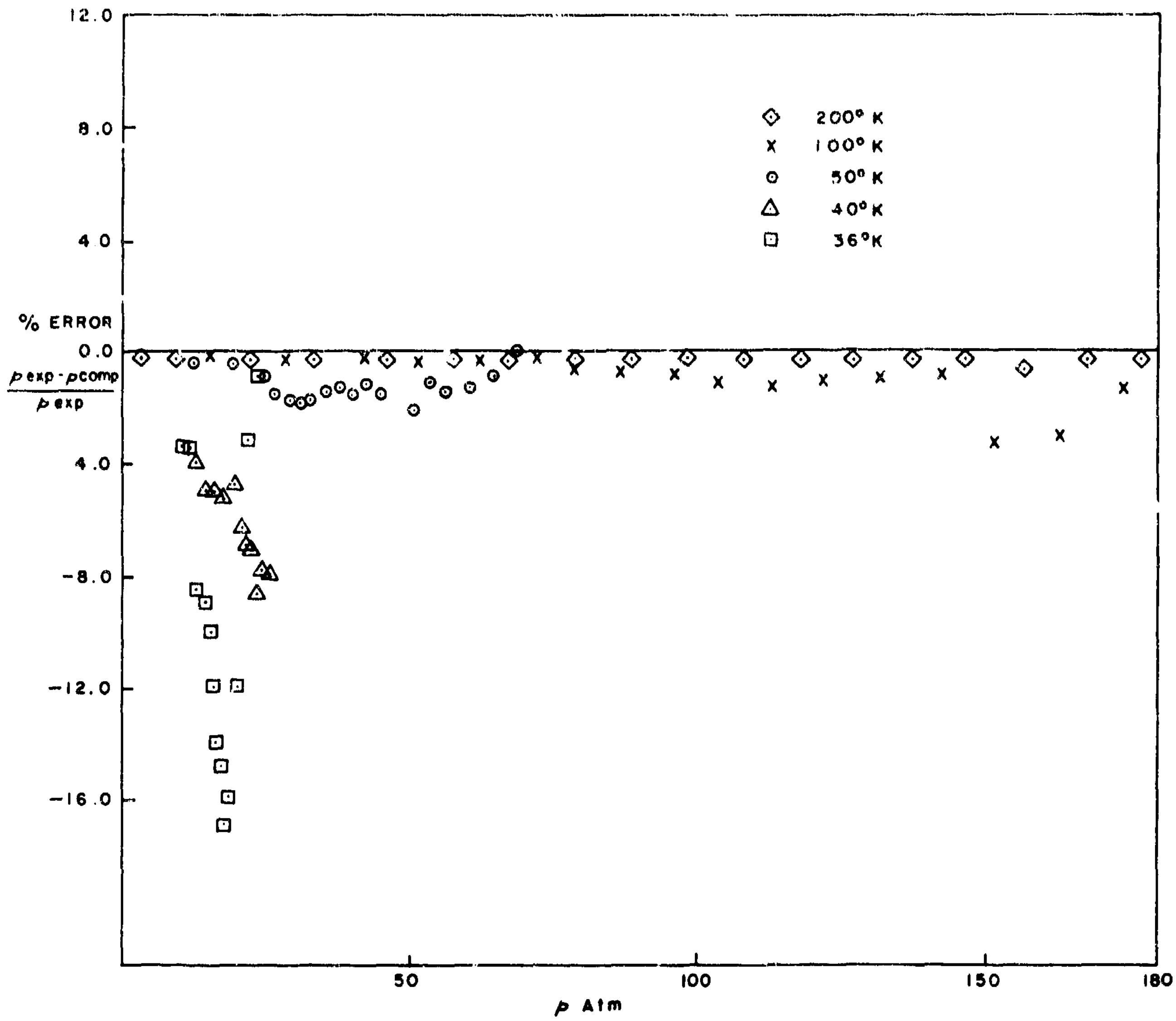

FIGURE 17. COMPARISON OF THE COMPUTED PRESSURES FOR HYDROGEN WITH EXPERIMENTAL PRESSURES

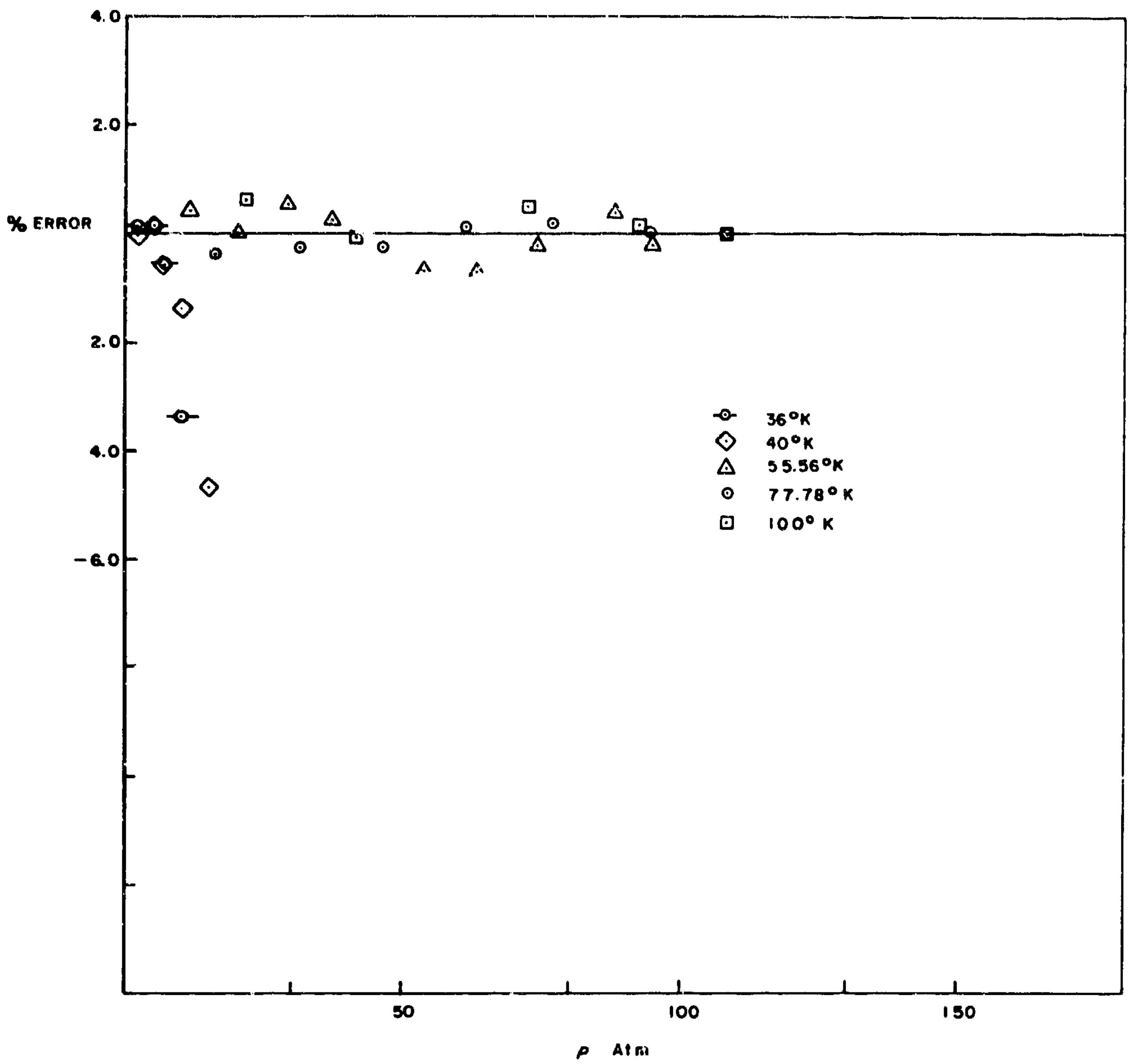

FIGURE 18. COMPARISON OF THE COMPUTED ENTHALPIES FOR HYDROGEN WITH THE EXPERIMENTAL DATA

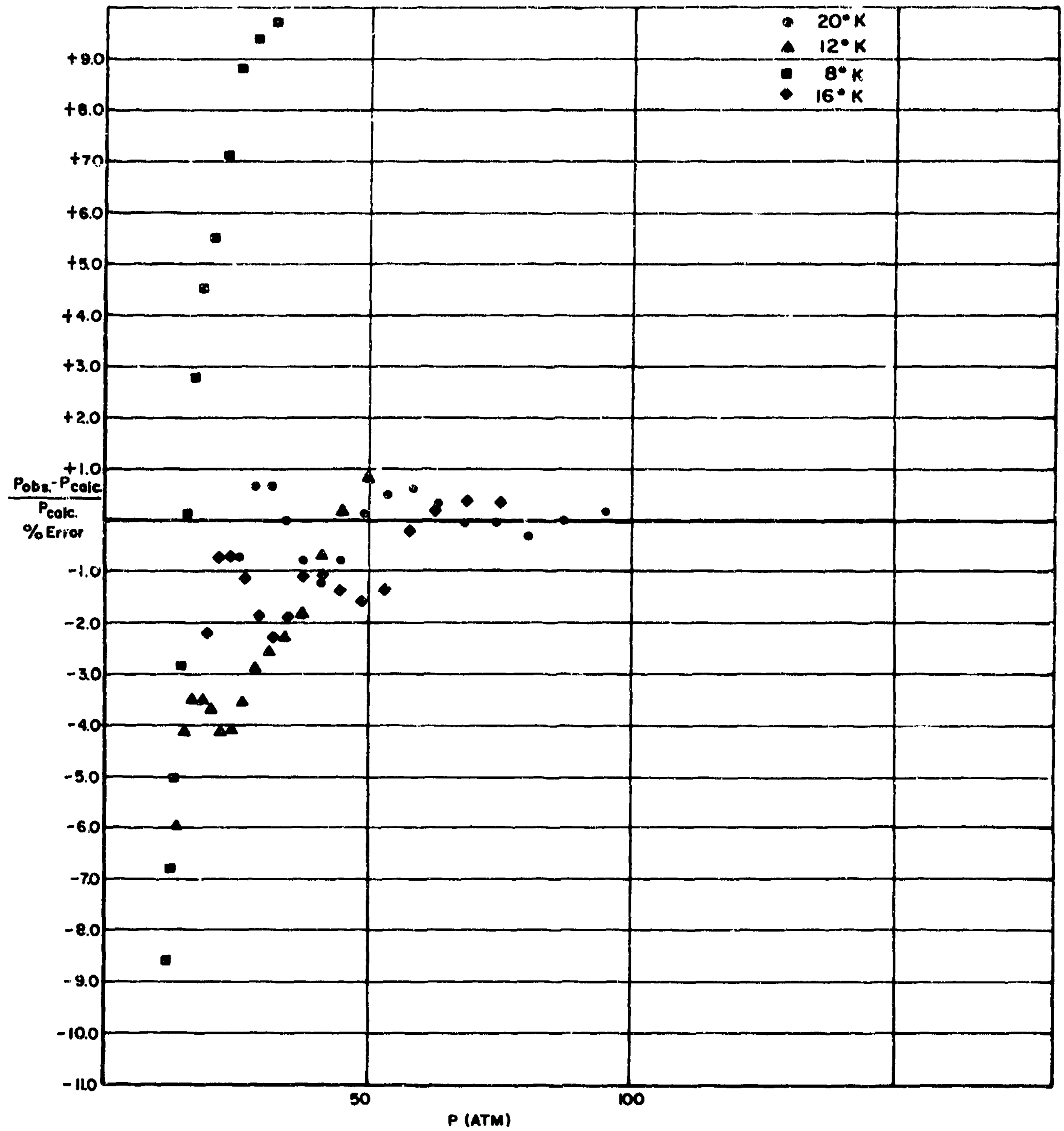

FIGURE 19. COMPARISON OF PREDICTIONS AND DATA FOR He^3 BETWEEN 8°K AND 20°K

becomes increasingly serious culminating in the inversion of the 6°K isotherm with respect to the 8°K isotherm. The correlation fails completely therefore at the lowest temperatures. This is not too surprising as He^3 has the largest quantum effects of all the molecules and furthermore obeys different statistics to He^4 and Ar. This simple approach is therefore not applicable to He^3 at temperatures below $\sim$12°K.

However, Figure 19 does show that the correlation is in very good agreement with the experimental data between 12°K and 20°K. It is therefore reasonable to expect that at temperatures above 20°K the correlation will predict values of the PVT surface accurate to $\sim$ 1.0% as the same approach gives excellent agreement at high temperatures for neon and hydrogen.

The results of this section establish the validity of the quantum version of the principle of corresponding states used to predict the equilibrium properties of gaseous He^3 at temperatures above 12°K. The following section applies the same basic approach to the calculation of the transport properties of He^3.

SECTION VII

THE TRANSPORT PROPERTIES OF He^3

There are very few data available for either the thermal conductivity or viscosity of He^3. Most data have been obtained for liquid He^3; Fairbank (13) has measured the thermal conductivity while Betts (4), Zinoveva (73) and Webeler et al (69) have measured the viscosity of liquid He^3. Apart from calculated values (29, 48) and Misenta's (46, 47) low pressure data on viscosity, there are no data available for gaseous He^3. A correlation based on the quantum version of the principle of corresponding states was therefore developed to predict the transport properties of gaseous He^3.

The quantum version of the principle of corresponding states as applied here requires equations for the viscosity and thermal conductivity of two gases other than He^3. The existing data for transport properties of gases are fragmentary and, apart from the equation of Rodgers and Williams for the viscosity of hydrogen (54), no satisfactory correlation based on an adequate amount of data is available for either viscosity or thermal conductivity. A survey of the existing data on the thermal conductivity of the simple gases showed that there were sufficient data on Ar (25, 28, 32-36, 55, 67, 68, 72), He^4 (3, 26, 19), and H_2 (19, 21, 34a, 35) to form the basis of an equation.

In some of the references the data are listed as functions of temperature and pressure, whereas in the correlations developed here, tabulations of temperature and density are required. Wherever density data were not provided in the reference, it was obtained from reference (17) for Ar, reference (39) for Ne, reference (41) for He^4, and reference (70) for H_2. At temperatures higher than those listed in the references, the classical principle of corresponding states was used to predict the density in conjunction with the equation for neon in (39).

Equations were developed to fit the thermal conductivity data of Ar and He^4 and used to predict the thermal conductivity of He^3. The prediction of the viscosity of He^3 was based on the existing equation for H_2 (54) and an equation which was developed for the viscosity of Argon. The details of the development and testing of the correlations are given in the following sections.

1. THE EQUATIONS FOR THE THERMAL CONDUCTIVITIES OF ARGON AND HELIUM^4

To obtain an equation for the thermal conductivity of argon, data were taken from the following sources:

Ikenberry and Rice (25)	20 points
Kannuluik and Carman (28)	5 points
Keyes (35)	1 point
Lenoir et al (38, 39)	22 points
Michels et al (43)	112 points
Rosenbaum et al (55)	51 points
Uhlir (67)	21 points
Vines (68)	4 points
Zeibland and Burton (72)	59 points

In all, 295 points at high densities were used at 10 temperatures over the range 90°K to 400°K (i.e., a reduced temperature range of T* from .75 to 3.4). Fifty data points at 1 atm were used ranging from 90°K to 1100°K. The data at 1 atm, k_o, were first obtained as a function of temperature and a plot of the excess thermal conductivity, $k-k_o$, versus density was made. This excess conductivity was found to be independent of temperature and could be represented by a form cubic in log ρ. The final form of the equation was:

$$k_{Argon} = n_1 + n_2T + n_3T^2 + n_4T^3 + n_5T^4 + n_6T^5 + n_7 \log T + \exp\left\{n_8 + n_9 \ln\rho + n_{10}(\ln\rho)^2 + n_{11}(\ln\rho)^3\right\} \quad (7)$$

(k is in cal/sec/cm/°K, ρ is in g/c.c.)

where

$n_1 = 2.31718$
$n_2 = 2.82841\,(10^{-2})$
$n_3 = -4.87681\,(10^{-5})$
$n_4 = 7.5992\,(10^{-8})$
$n_5 = 6.35609\,(10^{-11})$

$n_6 = +2.05425\,(10^{-14})$
$n_7 = -0.658875$
$n_8 = 2.62786$
$n_9 = 1.97295$
$n_{10} = 0.409007$
$n_{11} = 0.0642591$

Recalculation of the thermal conductivity using Equation (7) and comparison with the experimental data gave:

RMS = 0.035
Bias = 0.0035
Max. Error = 0.10

Most of these errors arise from scatter in the data, and a comparison with smoothed experimental data produced an RMS error of less than 0.01. Figure 20 shows a plot of the error versus density. There is no temperature dependence in the error.

The same approach was used to obtain an equation for the thermal conductivity of He^4. Data at 1 atm from 1^oK to 100^oK were obtained from the following sources:

Amdur (3)	10 points
Golubev and Shpagina (18)	47 points
Johnson and Grilly (26)	18 points

In all, 75 points were used in obtaining a curve fit. At elevated densities, nearly all of the data were from Reference 18 and ranged in temperature from 21^oK to 100^oK (T^* = 2. to 10.). There appeared to be a slight temperature dependence in the excess thermal conductivity of helium but there were not enough data to establish this definitely. Proceeding in the same way as for Ar, the following equation was obtained for the thermal conductivity of He^4.

$$k = n_1 + n_2 T + n_3 T^2 + n_4 T^3 + n_5 T^4 + n_6 T^5$$
$$+ n_7 \ln T + \exp\left\{ n_8 + n_9 \ln\rho + n_{10} (\ln\rho)^2 \right\} \qquad (8)$$

(k is cal/sec/cm/°K and ρ is g/cc)

where

n_1 = -0.442947
n_2 = 0.131161
n_3 = -1.18144 (10^{-4})
n_4 = -5.49586 (10^{-7})
n_5 = 3.16647 (10^{-9})
n_6 = 4.46314 (10^{-12})
n_7 = 1.36935
n_8 = 2.98112
n_9 = 0.155251
n_{10} = -0.229846

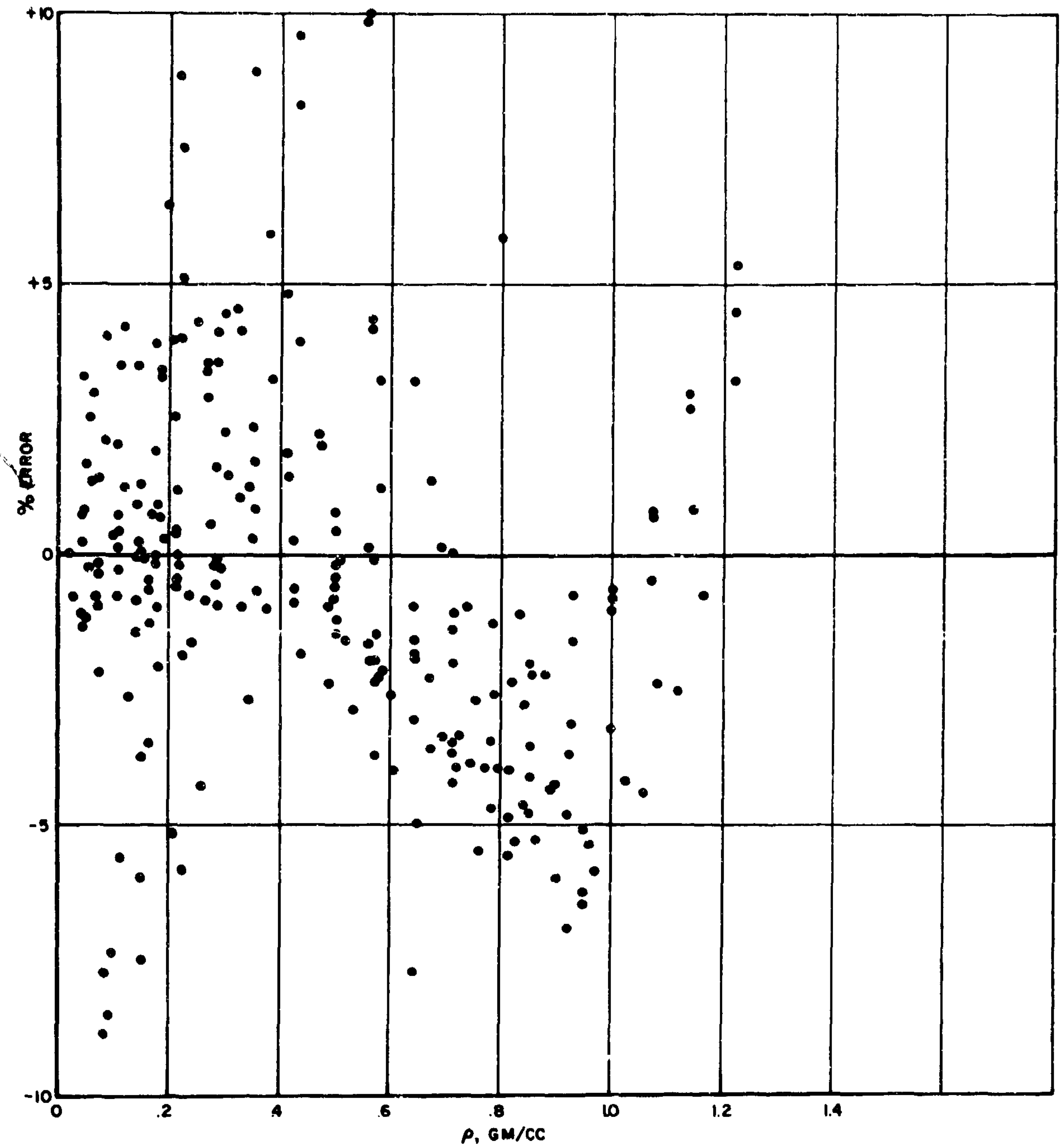

FIGURE 20. COMPARISON OF CALCULATED AND EXPERIMENTAL VALUES OF THE THERMAL CONDUCTIVITY OF ARGON AS A FUNCTION OF DENSITY

Comparison of the values of k calculated from the equation with the data gave:

RMS = 0.0284
Bias = -0.0015
Max. Error = 0.10

A plot of error versus density is given in Figure 21; there appears to be some slight temperature dependence in the errors, as noted previously for the excess thermal conductivity.

2. THE THERMAL CONDUCTIVITY OF Ne AND He^3

The equations developed for the thermal conductivity of Ar and He^4 can be used in conjunction with the quantum version of the principle of corresponding states to predict the thermal conductivity of Ne and He^3. The procedure is the same as was used in Section VI to predict the equilibrium properties of He^3. It is assumed that under the same reduced conditions the reduced thermal conductivity depends on the reduced de Broglie wavelength of the molecules. That is,

$$k^* = f_c^*(V^*, T^*) + f(\Lambda^*)\, f_1^*(V^*, T^*) \tag{9}$$

where k^* is the reduced thermal conductivity, $f(\Lambda^*)$ some function of the reduced de Broglie wavelength and f_c^* and f_1^* are universal functions which depend solely on the reduced temperature and volume. f_c^* and f_1^* for fixed values of T^* and V^* are found by using the equations for Ar and He^4 previously developed.

It remains then to specify the form of $f(\Lambda^*)$ and the reduction parameters. The parameters are listed in Table VII and are derived from the Lennard-Jones potential. They differ slightly from the parameters used in the equilibrium properties correlation. A plot of reduced thermal conductivity versus Λ^{*2} gives an approximately linear relationship so $f(\Lambda^*)$ was taken as Λ^{*2}.

Figure 22 shows a comparison of the values of the thermal conductivity of Ne at 25°C, 50°C, 75°C with the experimental data of Sengers (56). For neon these temperatures correspond to $T^* = 8.3$, 8.8, and 9.8. While there is a definite trend with density, the worst case at the highest density is still $< 10\%$ in error and the average error is $< 5\%$. In view of the extrapolation of the high density of argon data from $T^* = 4.$ to $T^* \simeq 10$, the agreement is very good.

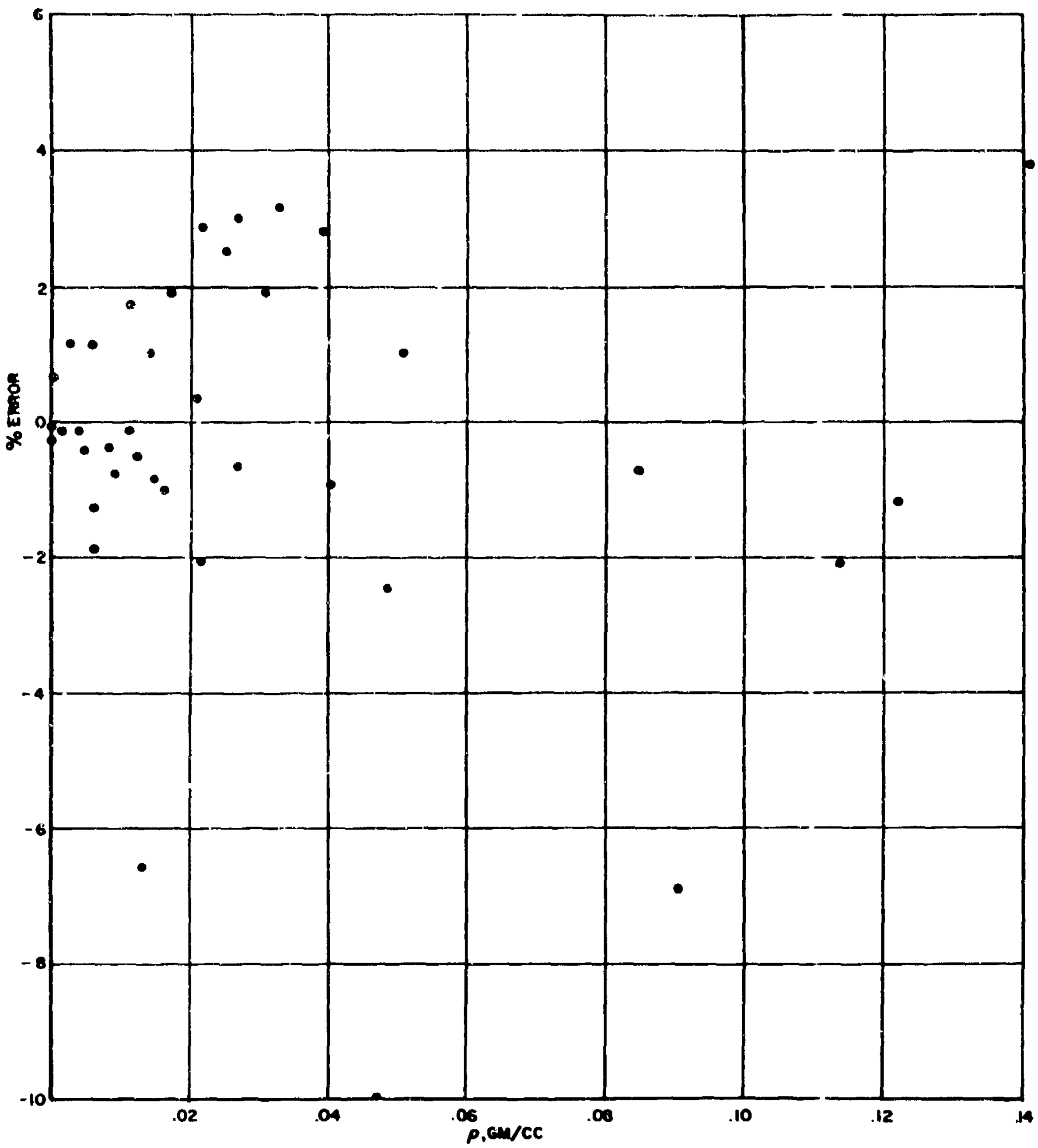

FIGURE 21. COMPARISON OF CALCULATED AND EXPERIMENTAL VALUES OF THE THERMAL CONDUCTIVITY OF He^4 AS A FUNCTION OF DENSITY

TABLE VII

THE REDUCTION PARAMETERS FOR THE TRANSPORT PROPERTIES

	ϵ/k	σ	(μ)	(K)
	°K	°A	μ Poises	10^5 J/Sec/Cm/°K
Ar	119.8	3.405	903.27	1880.24
Ne	35.6	2.789	507.530	2215.49
H_2	37.0	2.968	148.43	6121.67
He^4	10.8	2.556	147.98	3078.71
He^3	10.8	2.556	128.155	3500.

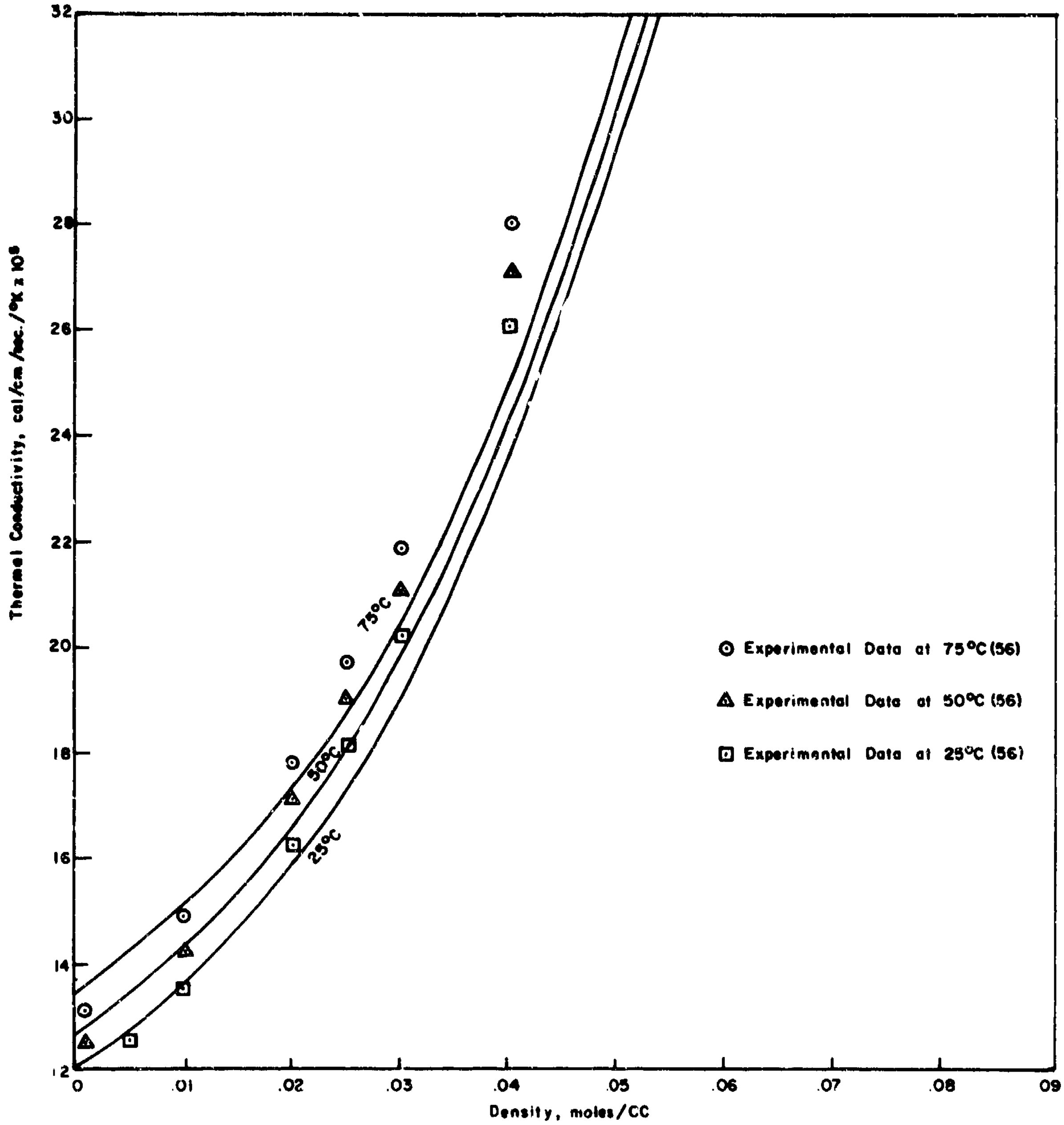

FIGURE 22. COMPARISON OF CALCULATED AND EXPERIMENTAL VALUES OF THE THERMAL CONDUCTIVITY OF NEON

The only other test that can be made is with the low density measurements of Fokkens et al (16) and the calculated values of Keller (29) and Monchick et al (48). These quantities are compared in Figure 23 where the agreement is ± 6% in the range 2°K to 20°K. The low density region is where quantum effects will be smallest, so good agreement in that region does not guarantee as good behavior at higher densities.

3. THE VISCOSITY OF HYDROGEN AND ARGON

The equation of Diller (11) was used to describe the viscosity of H_2 as a function of temperature and pressure. This equation is:

$$\mu_{H_2} = n_1 \left[T^{3/2}/(T + n_2)\right] \left[(T + n_3)/(T + n_4)\right] + \exp \left\{ n_5 + \ln\rho + n_6 \rho^{3/2} - n_7 \exp(n_8 \rho) + 1/T \left[n_9 + n_{10} \left[\left(\frac{\rho}{n_{11}}\right)^6 - \left(\frac{\rho}{n_{11}}\right)^{3/2}\right] - n_{12} \exp\left\{-n_{13} \left(\frac{\rho^2}{n_{11}}\right)\right\}\right]\right\} \qquad (10)$$

where

$n_1 = 8.5558$	$n_5 = 5.7694$	$n_9 = 10.$
$n_2 = 19.55$	$n_6 = 65.0$	$n_{10} = 7.2$
$n_3 = 650.39$	$n_7 = -6.(10^{-6})$	$n_{11} = 0.07$
$n_4 = 1175.9$	$n_8 = 127.2$	$n_{12} = 17.63$
		$n_{13} = 58.75$

It has an estimated accuracy of ± 3% over the range 35°K to 300°K.

For the viscosity of argon, it was necessary to develop an equation to represent the viscosity as a function of temperature and volume. Data were taken from the following sources:

Bonilla et al (5)	22 points
Filoppova and Ishkin (14)	36 points
Flynn et al (15)	27 points
Kestin and Leidenfrost (32)	15 points
Kestin and Wang (33)	48 points
Kestin and Whitelaw (34)	48 points

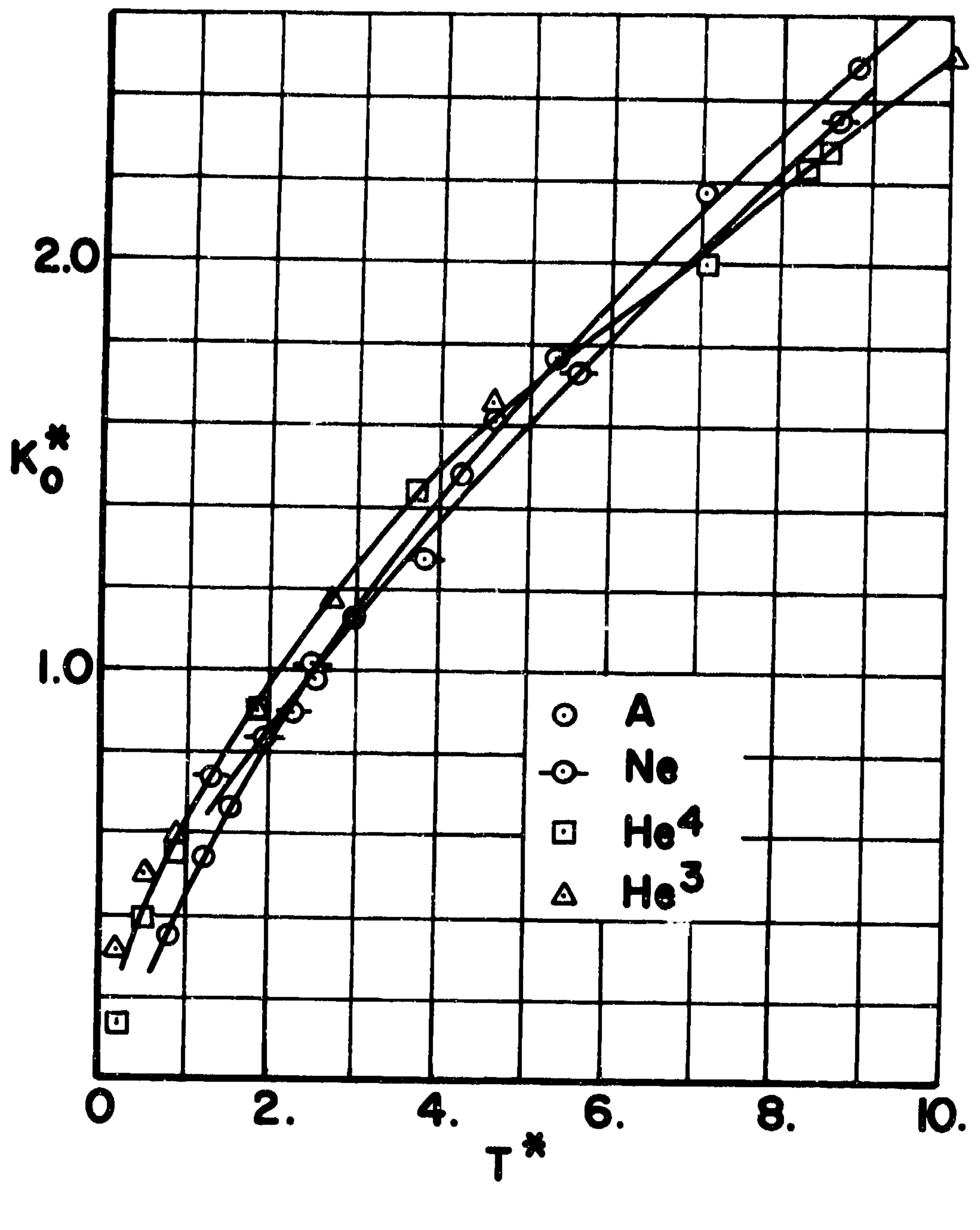

FIGURE 23. REDUCED THERMAL CONDUCTIVITY AT LOW PRESSURE VERSUS REDUCED TEMPERATURE FOR SEVERAL GASES

Michels et al (44)	96 points
Reynes and Thodos (50)	20 points
Rigby and Smith (51)	15 points
Zhdanova (71)	55 points

A total of 382 points were used in the temperature range from 88°K to 1100°K; only data at 1 atm were available at temperatures above 425°K, which corresponds to a reduced temperature of 3.5.

The data of Zhdanova were the only information below 120°K so it was unfortunate that his data were presented only in the small scale plot in Reference 71 from which the viscosity had to be read directly. The data at 1 atm, μ_0, from 88°K was first curve fitted with respect to temperature and plots prepared of the excess viscosity, $\mu - \mu_0$. The excess viscosity was found to depend markedly on temperature as previously observed by Rodgers and Brickwedde (53). A form to take account of this temperature dependence in the excess viscosity was devised and the final expression was:

$$\mu = n_1 + n_2 T + n_3 T^2 + n_4 T^3 + n_5 T^4 + n_6 T^5 + n_7 \log T$$

$$\exp \left\{ n_8 + n_9 \exp^{-n_{10}(T-n_{11})^2} + \rho \left(n_{12} + \frac{n_{19}}{T} + \frac{n_{14}}{T^2} \right) \right.$$

$$\left. + \left(n_{15} + \frac{n_{16}}{T} + \frac{n_{17}}{T^2} \right) \exp - \rho \left(n_{18} + \frac{n_{19}}{T} + \frac{n_{20}}{T^2} \right) \right\} \qquad (11)$$

where μ is in micro poises and ρ in gm/cc and

$n_1 = 105.286$	$n_{11} = 150.$
$n_2 = 1.32743$	$n_{12} = 3.55022$
$n_3 = -0.143726\,(10^{-2})$	$n_{13} = -452.768$
$n_4 = 0.113534\,(10^{-5})$	$n_{14} = +38733.0$
$n_5 = -0.465087\,(10^{-9})$	$n_{15} = 1.77827$
$n_6 = 0.744623\,(10^{-13})$	$n_{16} = -276.24$
$n_7 = -30.5945$	$n_{17} = 376273.$
$n_8 = 3.718$	$n_{18} = 23.8747$
$n_9 = 0.599937$	$n_{19} = 644424.$
$n_{10} = -0.644582\,(10^{-4})$	$n_{20} = 499125.$

Comparison of the values predicted by Equation 11 with the experimental data gave, excluding those points circled in the diagram:

RMS = 0.028
Bias = 0.003
Max. Error = 0.08

A plot of the error versus density is shown in Figure 24. There was no temperature dependence in the error and most of the errors can be attributed to scatter in the data from different authors as a comparison with smoothed data produced an RMS error of $<1\%$. Because of the temperature dependence of the excess viscosity any extrapolations in temperature will give less reliable values of the viscosity than was the case for the thermal conductivity where the density dependence of thermal conductivity was independent of the temperature.

The circled points in Figure 24 show scatter of $>10\%$ from the correlation. All the circled points were taken from Zhdanova (71); as noted above they were obtained from a small scale figure which itself showed some scatter in the data. It seems reasonable to conclude that the scatter observed is due to a combination of (a) error in reading the figure and (b) scatter in Zhdanova's data. The fact that Zhdanova's data is approximately symmetrically scattered about the predictions of the correlation suggest that the correlation should be valid down to 130 °K. Ignoring the data of Zhdanova the RMS error is 0.028 which is highly satisfactory.

4. THE PREDICTION OF THE VISCOSITY OF NEON AND HELIUM^3

The same basic approach as was used in the prediction of the thermal conductivity and PVT properties of He^3 was used to predict the viscosity of He^3. The same reduction parameters as were used for the thermal conductivity, listed in Table VII, were used in the reduction of the viscosity data. The data available for the reduced viscosity of the rare gases at low densities were plotted at fixed reduced temperatures to establish the dependence of the viscosity on Λ^*. The graph in Figure 25 shows that μ_o^* varies approximately linearly with Λ^{*2}. Therefore, one may write:

$$\mu_o^* = f_c^*(V^*T^*) + \Lambda^{*2} f_1(V^*T^*) \tag{12}$$

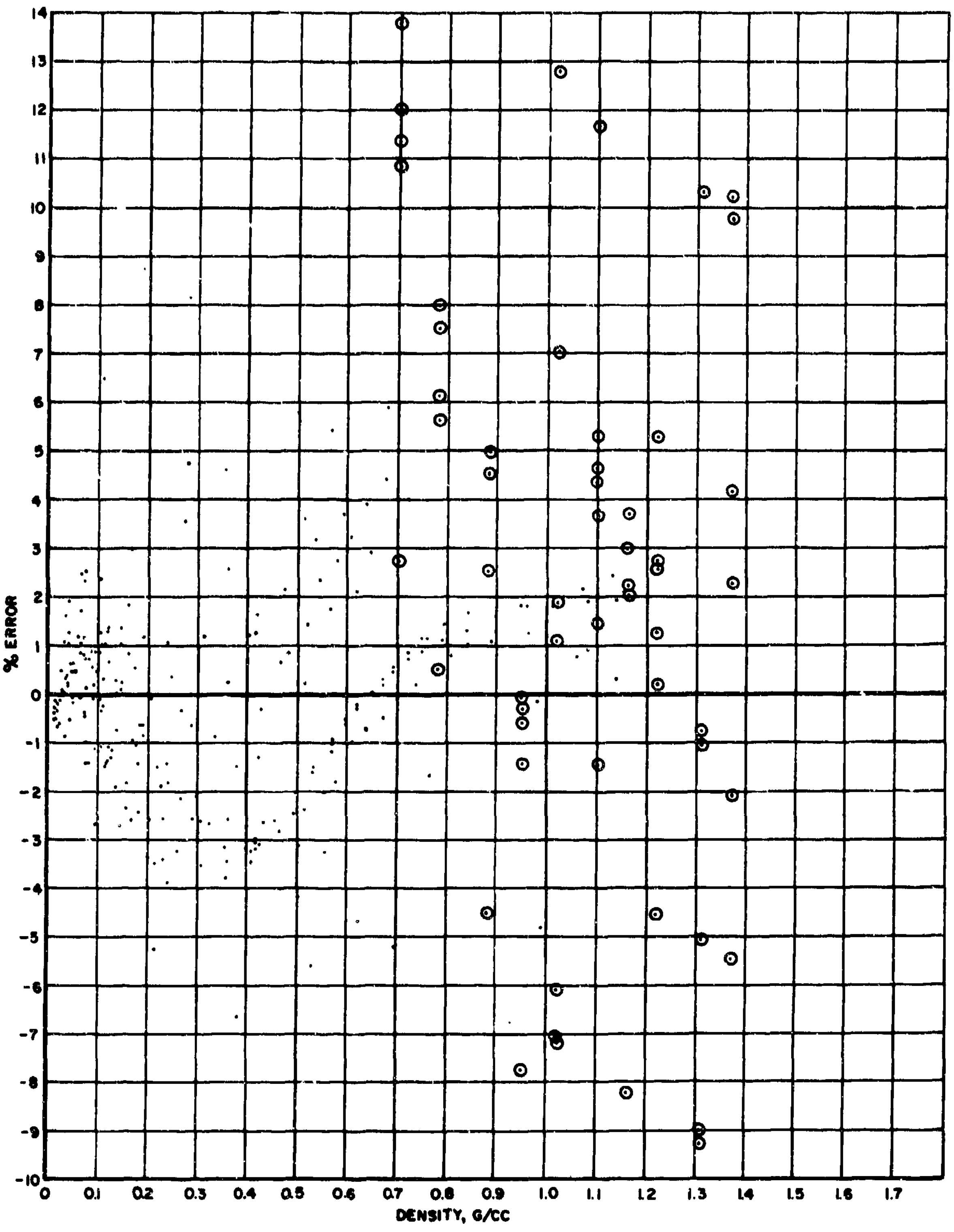

FIGURE 24. ERROR PLOT FOR THE CALCULATED AND EXPERIMENTAL VISCOSITIES OF ARGON

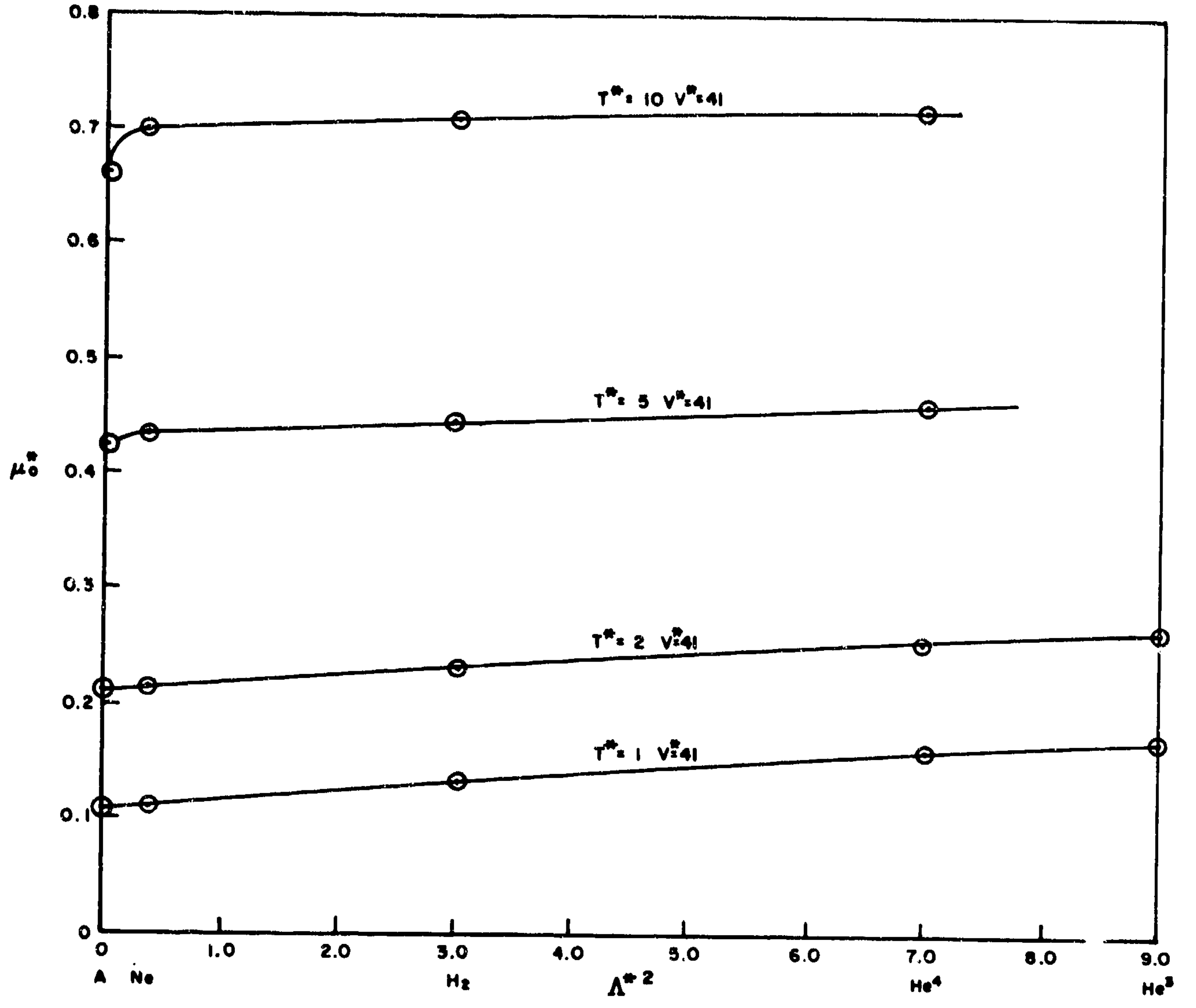

FIGURE 25. REDUCED VISCOSITY VERSUS REDUCED de BROGLIE WAVELENGTH SQUARED FOR SEVERAL GASES AT FIXED REDUCED TEMPERATURE AND VOLUME

The equations for argon and hydrogen were used to establish f_c and f_1 at each reduced temperature and volume. The predictions of the viscosity of neon at 25°C, 50°C, and 75°C using this approach are compared with the experimental data in Figure 26. The maximum error is ± 10% and the average ± 4%. Unfortunately, data at lower temperatures and elevated densities are not available, so a test at low temperatures is not possible. The only other comparison that can be made is with the low pressure data of Misenta and Becker (46, 47) and the calculated values of Monchick et al (48) for the viscosity of gaseous He^3. This comparison was made and it was found that the predicted values differ by ± 5% at temperatures above 12°K. 12°K corresponds to $T^* = \sim 1.2$ which is the lowest reduced temperature at which the equation for argon is valid; no comparisons below 12°K were attempted because of this limitation.

5. RANGE OF VALIDITY OF THE CORRELATIONS FOR THE VISCOSITY AND THERMAL CONDUCTIVITY

The correlations were designed to predict the viscosity and thermal conductivity of He^3 at temperatures up to 100°K and pressures up to 100 atm. This corresponds to reduced ranges of $T^* = 0.1$ to 10. and $V^* = \sim 1.7$ to ~ 800 (the reduced volume of He^4 at 1 atm and 100°K). Thus far no indication has been given of the range of validity of the correlations for the viscosity and thermal conductivity, though as noted in Section VI the PVT correlation obtained from the quantum version of corresponding states is not valid $T^* \leq 1.2$. However, neither viscosity nor thermal conductivity change as much with volume as pressure does near the critical. The failure of the transport property correlation at low temperatures should not be so severe for transport properties as it was for the PVT surface.

Strictly the correlations are valid only in the region for which data are available over the appropriate density range. However, it proved possible to extrapolate the correlations safely as is shown below.

The thermal conductivity equation for He^4 is based on data at 1 atm from $T^* = 0.1$ to 10 and at higher densities from $T^* = 2.$ to 10. But since the excess thermal conductivity is independent of temperature, it seems safe to extend the equation at all densities for the temperature range in which there is data at 1 atm. The same considerations apply to the Ar correlation for thermal conductivity which is based on data at 1 atm from $T^* = 1.0$ to 10. and data at elevated densities from $T^* = 1.$ to 5.

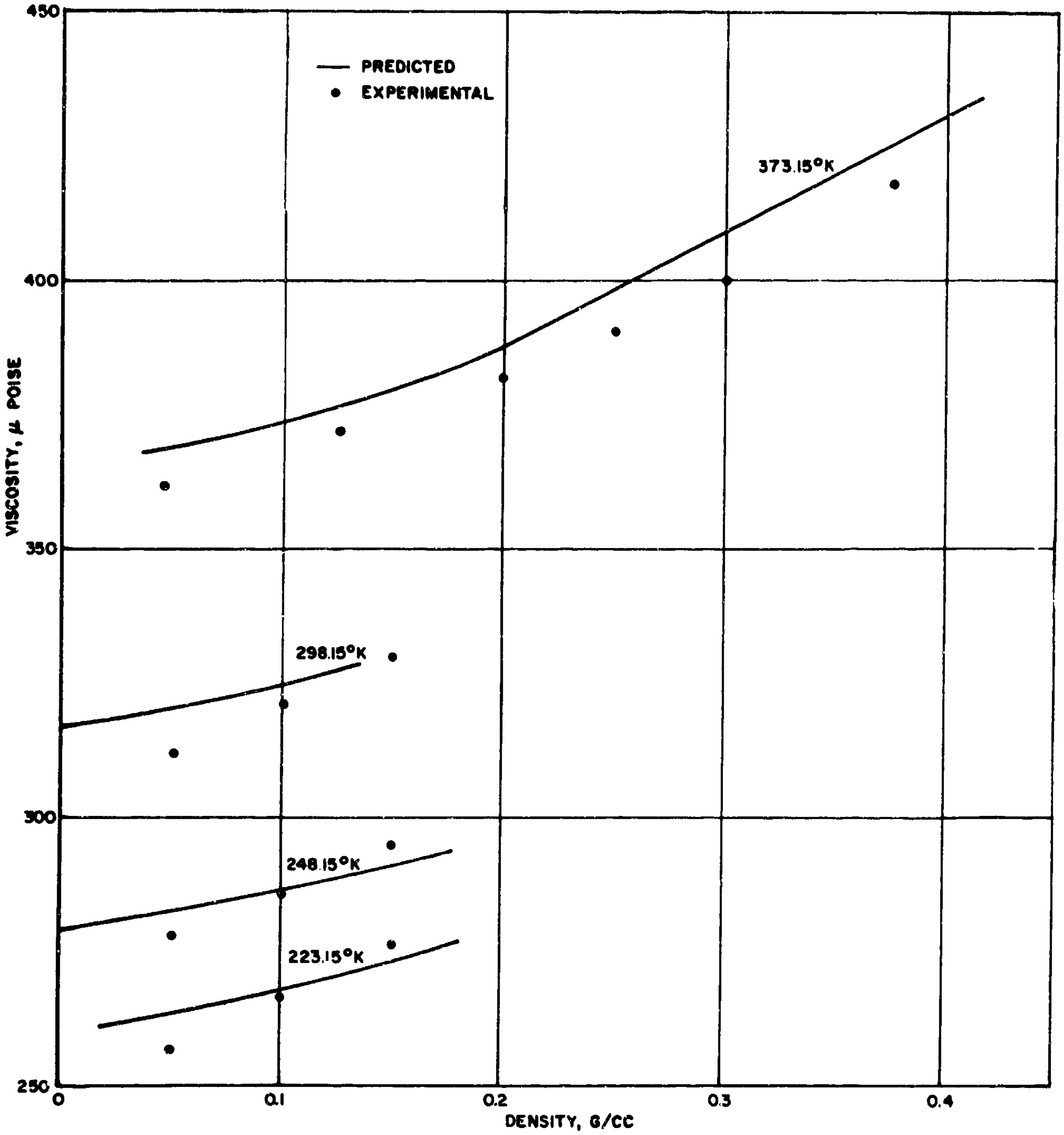

FIGURE 26. COMPARISON OF CALCULATED AND EXPERIMENTAL VISCOSITIES OF NEON

The viscosity correlation is not as easy to extend, as the excess viscosity depends on temperature somewhat for both hydrogen and argon. The correlation for hydrogen extends over the range $T^* = 1.$ to $10.$ and $V^* = 1.7$ to $\sim 1000.$ For Ar there is data at 1 atm from $T^* = 1.1$ to $10.$ and at elevated densities from $T^* = 0.75$ to $5.$ However, the agreement with the neon data at $T^* = 10.$ shows that extrapolation of the data to higher temperatures is justified.

It seems safe to say, therefore, that the correlations are valid over the range of $T^* = 1.1$ to $10.$ and $V^* = 1.7$ to $1000.$ It is not possible to say anything further about the accuracy of the correlations at low temperatures in the absence of data. Accordingly, the transport coefficients listed for gaseous He^3 between $12^\circ K$ and $100^\circ K$ should be accurate to $\pm 10\%$. The treatment of the region below $10^\circ K$ is discussed in Section VIII.

SECTION VIII

THE THERMODYNAMIC PROPERTIES OF He^3

The data and correlations discussed in the preceeding sections describe the PVT, enthalpy, entropy, thermal conductivity and viscosity of He^3 from $\sim 4^oK$ to 100^oK at pressures of up to 100 atm. The purpose of this section is to combine this information with the data available for the liquid and latent heat of vaporization from 1^oK to 100^oK in a consistent set of tables and diagrams which are in convenient form for reference purposes. Since in most cases the temperature and pressure are known variables, it is convenient to list the data at fixed temperature and pressure. A Mollier diagram was also prepared with P and V and T as parameters. The details by which the tables and diagrams were produced are dicussed below.

1. THE VAPOR-LIQUID BOUNDARY

The vapor pressure equation of Sherman, Sydoriaks and Roberts (60-63) is:

$$\ln(p) = \frac{n_1}{T} + n_2 + n_3 T + n_4 T^2 + n_5 T^3 + n_6 T^4 + n_7 \ln T \qquad (13)$$

(p is in mm Hg at 0^oC, T is in ^oK)

where

$n_1 = -2.49174$	$n_4 = 0.198608$
$n_2 = 4.80386$	$n_5 = -0.0502237$
$n_3 = -0.286001$	$n_6 = 0.00505486$
	$n_7 = 2.24846$

This equation defines the 1962 He^3 temperature scale in the region 0.2^oK to 3.324^oK and is accurate to 0.001^oK. The equation also defines the derivative dp/dT in the same temperature range and was used in the determination of the latent heat of He^3.

The Clausius-Clapeyron equation:

$$\Delta H = \frac{dp}{dT} \cdot T \, \Delta V \qquad (14)$$

was used in conjunction with the data of Sherman (67) and Keller (30)

and Equation 13 to obtain the latent heat of He^3 from 0.2^oK to 3.324^oK. The values calculated in this way agree to within 0.5% with the limited measurements of Abrahams et al (1) in the region 0.2^oK to 2.1^oK. There was considerable disagreement between the data of Sherman (67) and Keller (30) above $2.8^\circ K$ and the data of Sherman were preferred. The calculated latent heats were used in compiling Table VIII which lists the properties of He^3 on the vapor liquid boundary.

2. THE LIQUID REGION

The work of Sherman and Edeskuty (59) tabulates the molar volume and entropy of compression for liquid He^3 from 1^oK to 3.3^oK at even pressures. These data were referred to the same standard state, i.e., the ideal gas at 3.1905^oK and 1 atm, as was used in the correlations for entropy and enthalpy and tabulated without any further modification, other than conversion to the appropriate units. The enthalpy was obtained using Equation 15:

$$\Delta H = + T \Delta S_c - \int p dV \qquad (15)$$

and the internal energy change was obtained from ΔH. The integration over V was performed graphically. Some data exists for the thermal conductivity and viscosity of liquid He^3 and wherever they were available they were included in the tables but no attempt was made to supplement the experimental values by correlations.

3. TABULATION OF THE DATA

There were certain problems in obtaining a set of consistent tables for the properties of He^3 between 1^oK and 100^oK. The necessity of using two correlations for the PVT data between 4^oK and 100^oK and resorting to the tabulations of Sherman and Edeskuty (59) for the compressed liquid produced some discontinuities in the properties such as entropy and enthalpy. To reduce these effects to a minimum, the data were smoothed in the following way. Isopycnals of S (or H) versus T were made and any discontinuities were smoothed graphically. The errors in P and V were much smaller and a composite diagram of the data from 1^oK to 20^oK of Z vs T produced a continuous diagram with no discernible discrepancies in the form of the isobars. In this way, the most consistent set of thermodynamic data were produced.

There were difficulties associated with the transport properties correlations also. As noted in Section VII these correlations are

TABLE VIII

THE VAPOR LIQUID BOUNDARY

	Liquid			Vapor			
Temp. $^{\circ}K$	Vol. C.C./G.	Enthalpy J./G.	Entropy J./G./$^{\circ}K$	Vol. C.C./G.	Enthalpy J./G.	Entropy J./G./$^{\circ}K$	Press. Atm.
1.000	12.220	-5.689	2.28	1724 130	6.748	14.717	0.012
1.200	12.270	-5.261	2.952	1020.411	8.028	14.023	0.027
1.400	12.360	-4.754	3.396	649.350	9.268	13.411	0.051
1.600	12.470	-3.970	3.857	438.607	10.464	12.878	0.086
1.800	12.620	-3.473	4.006	307.589	11.603	12.382	0.135
2.000	12.820	-2.637	4.258	222.221	12.675	11.914	0.199
2.200	13.080	-1.545	4.554	164.469	13.668	11.469	0.280
2.400	13.430	-0.235	4.872	124.088	14.566	11.039	0.380
2.600	13.968	1.163	5.176	95.790	15.371	10.641	0.501
2.800	14.255	3.962	6.130	83.892	16.397	10.571	0.644
3.000	15.485	5.277	5.977	55.310	16.321	9.658	0.725
3.200	17.197	8.436	6.541	39.108	15.975	8.897	1.010
3.324	23.935	13.252	7.499				1.15

designed for the gas phase at temperatures above $T^* = 1.1$ which for He^3 corresponds to $\sim$ 11°K. There were some data in the liquid region for both thermal conductivity and viscosity, and where available, these data have been included in the tables. No attempt was made to calculate values for the transport properties of the liquid. For the gas phase there seemed to be a reasonable way in which the data could be extrapolated to lower temperatures. Reference to the work of Diller (12) and of Zhdanova (71) shows that at constant volume the viscosity of both hydrogen and argon varies linearly with temperature. It would seem therefore that the viscosity of He^3 versus temperature at constant volume will behave similarly. Such extrapolations were carried out for several volumes and then cross-plotted at constant temperature to obtain the viscosity corresponding to a given pressure. All the gaseous viscosity data below 12°K were obtained in this way as the correlation for the viscosity of argon was not valid for reduced temperatures of $\lessdot$ 1.1. The values obtained in this way are not as reliable as the high temperature values and are not included in the report.

The extrapolations of the thermal conductivity correlation posed fewer problems. Agreement with the calculated values of Keller (29) and Monchick et al (48) is within 10% even at 2°K. The correlation predicts a value of 0.86 cal/sec/cm/°K at p = 0.165 atm, compared with the calculated value of 0.92 cal/sec/cm/°K. The values for the thermal conductivity of gaseous He^3 obtained from the correlation were not modified and were accepted at temperatures down to 4°K.

To obtain the tables listed in Appendix II, a computer program was written which incorporated all the correlations developed in Sections V, VI, and VII. An iteration calculated the volume corresponding to a given pressure at a fixed temperature. Using this volume, the thermodynamic properties were calculated for that point with fixed pressure, and temperature and were printed out. As noted in Section V the correlation of the data from 4°K to 20°K was unable to represent the HVT and SVT surfaces accurately. To obtain the tables listed in Appendix II, the high temperature correlation was used to represent the PVT, HVT and SVT surfaces from 20°K to 100°K. Below 20°K the equation (3) was used to present the data wherever it was valid but below 10°K it was necessary to use mainly experimental data for H and S supplemented by the corrected values at low densities where data were lacking. For the liquid portion of the tables, the set data for a given

temperature and pressure were obtained graphically by hand and punched onto a card which was then read in by the program and the contents printed out as part of the table without any modifications. Where smoothing operations were necessary, the values listed in the table were altered also so that the tables in Appendix II are as consistent as possible.

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APPENDIX I

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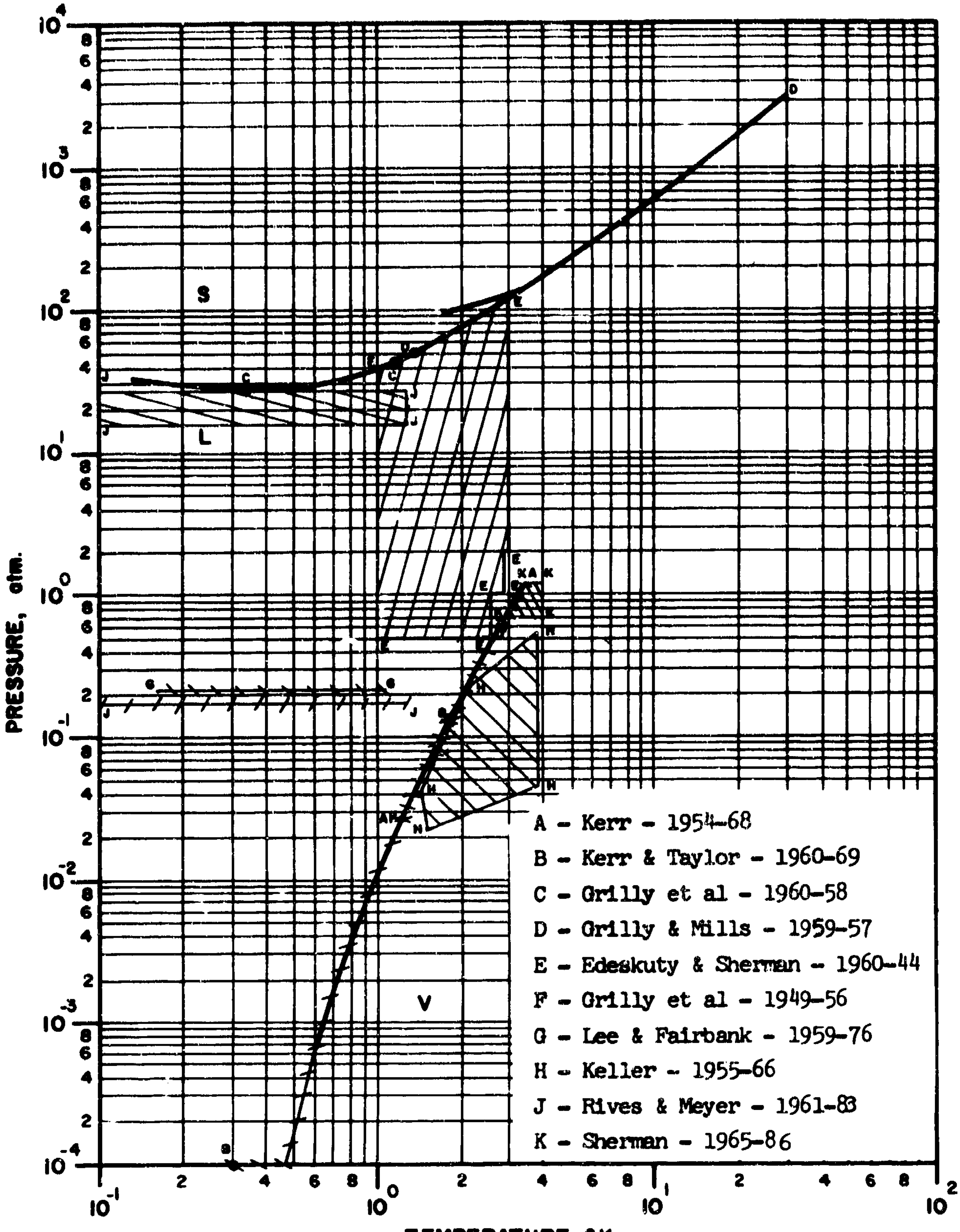


Figure 1. Available Experimental PVT Data for Helium-3

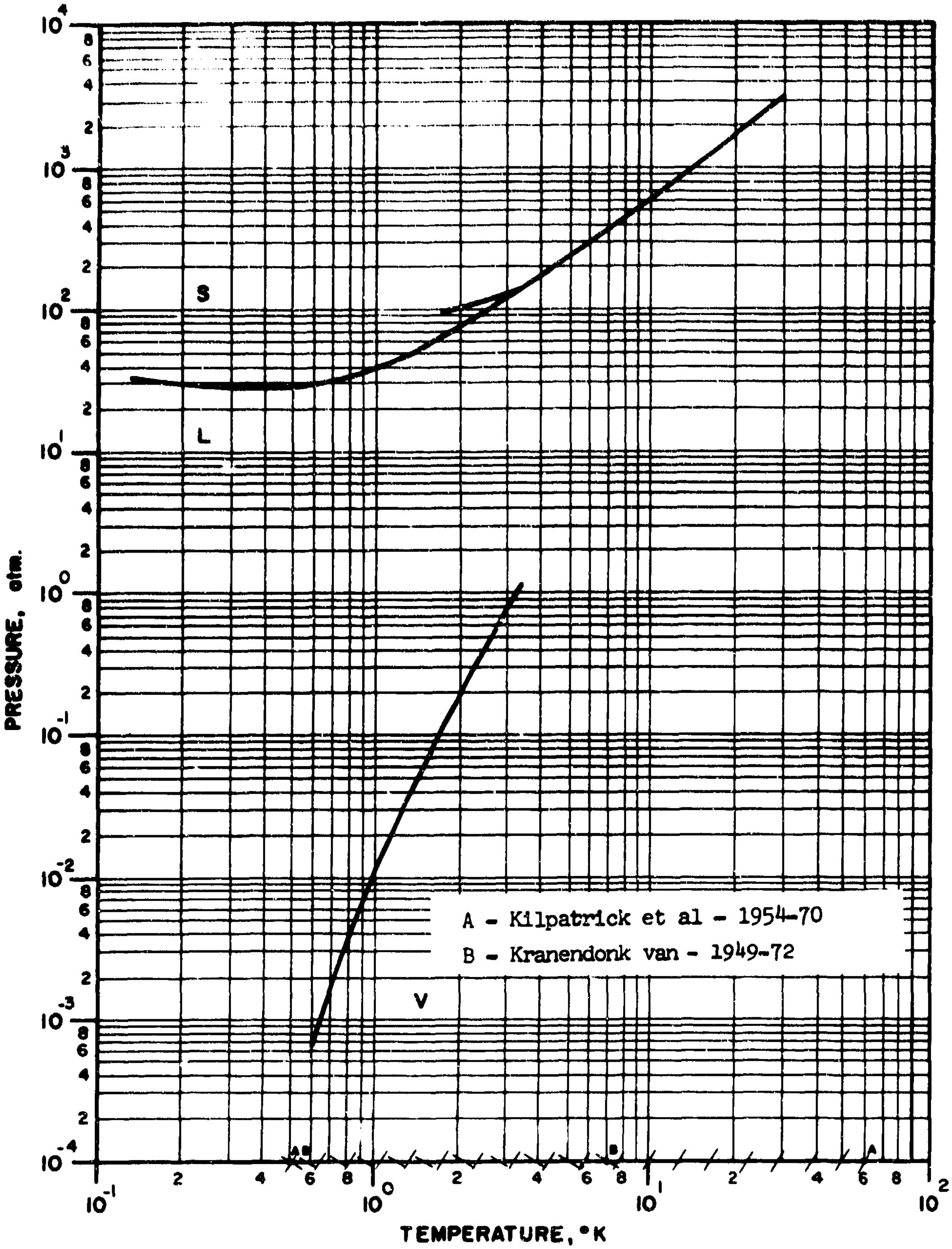


Figure 2. Available Calculated Virial Coefficient Data for Helium-3

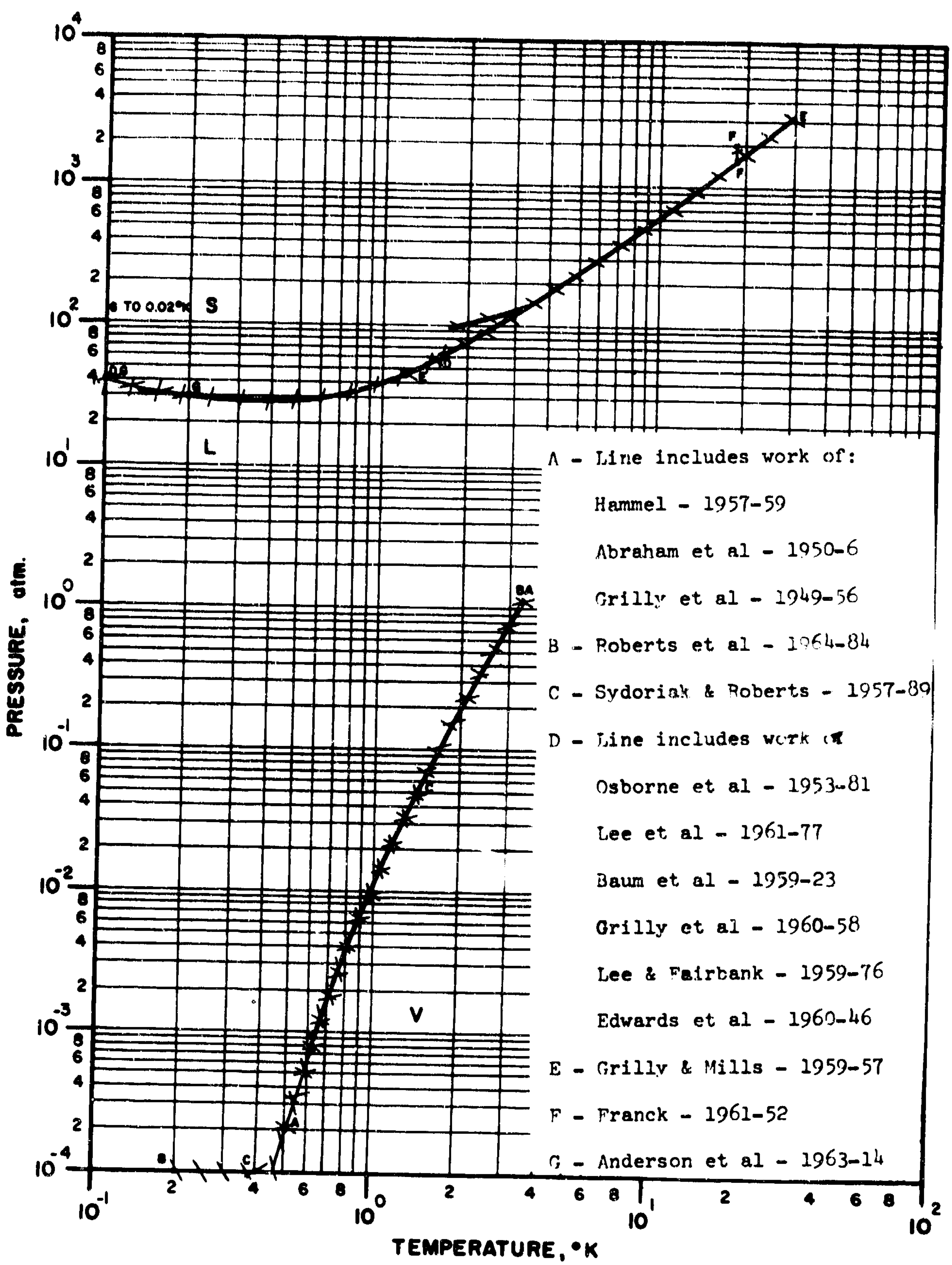


Figure 3. Available Experimental Phase Equilibrium Data for Helium-3

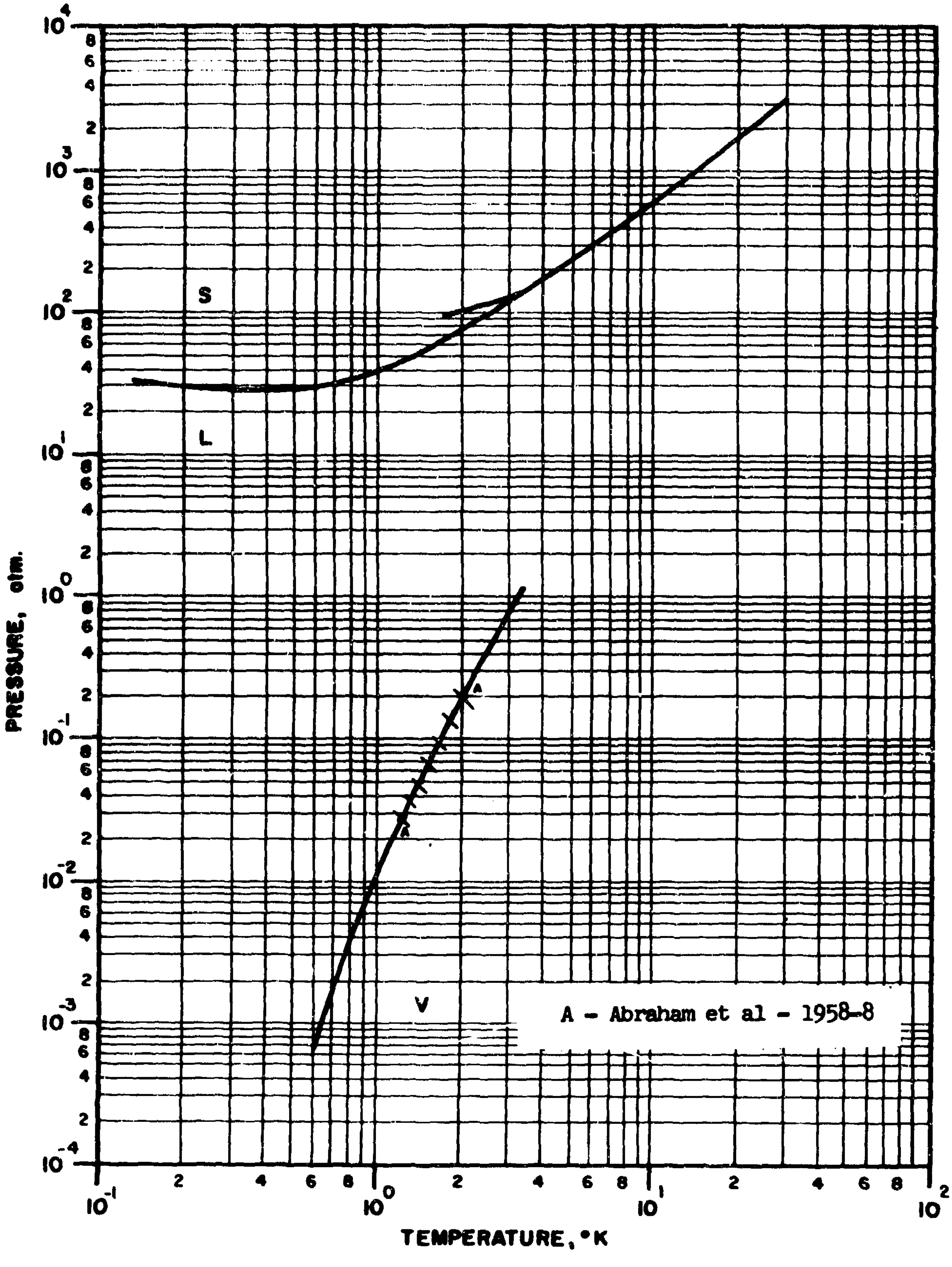


Figure 4. Available Experimental Latent Heat Data for Helium-3

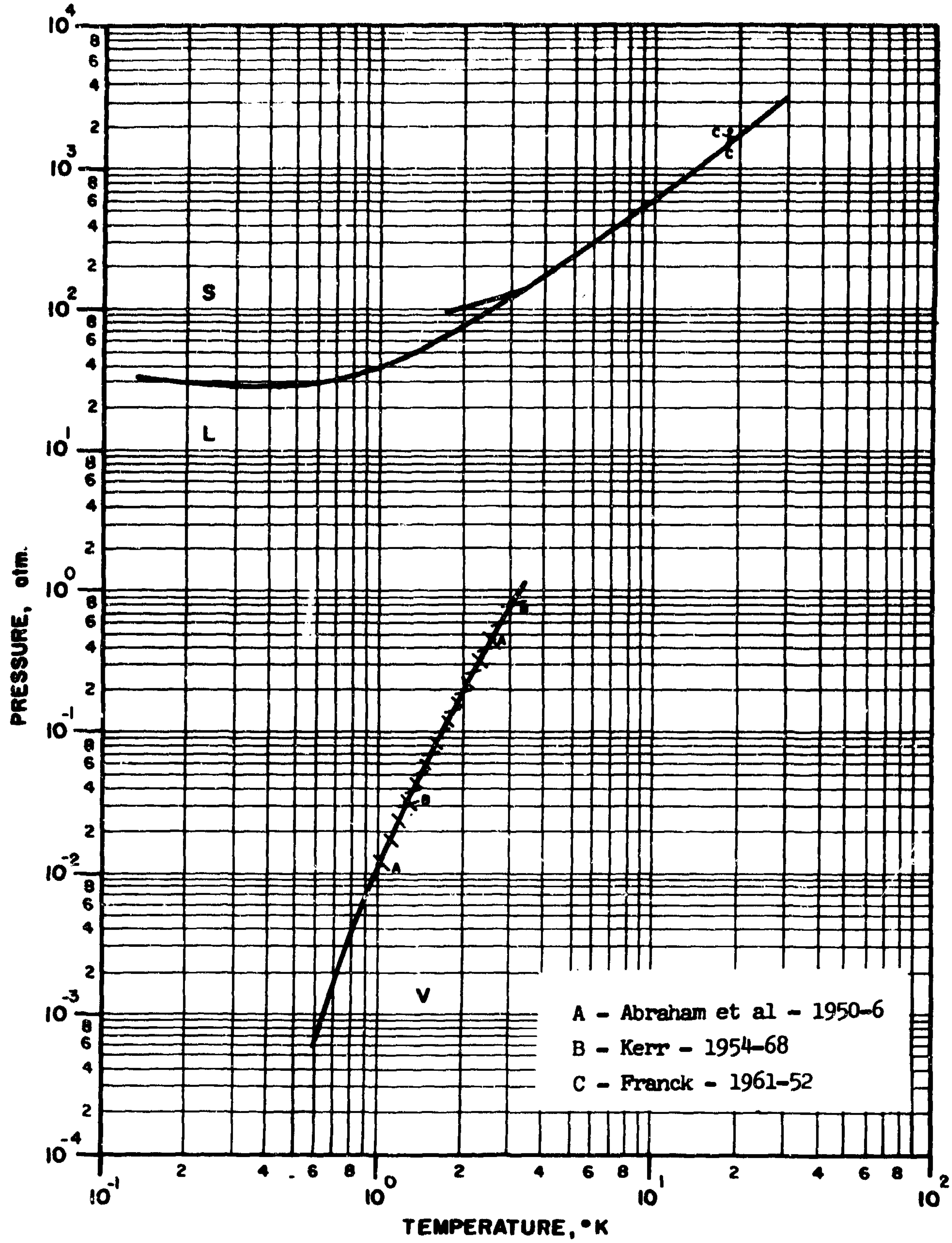


Figure 5. Available Calculated Latent Heat Data for Helium-3

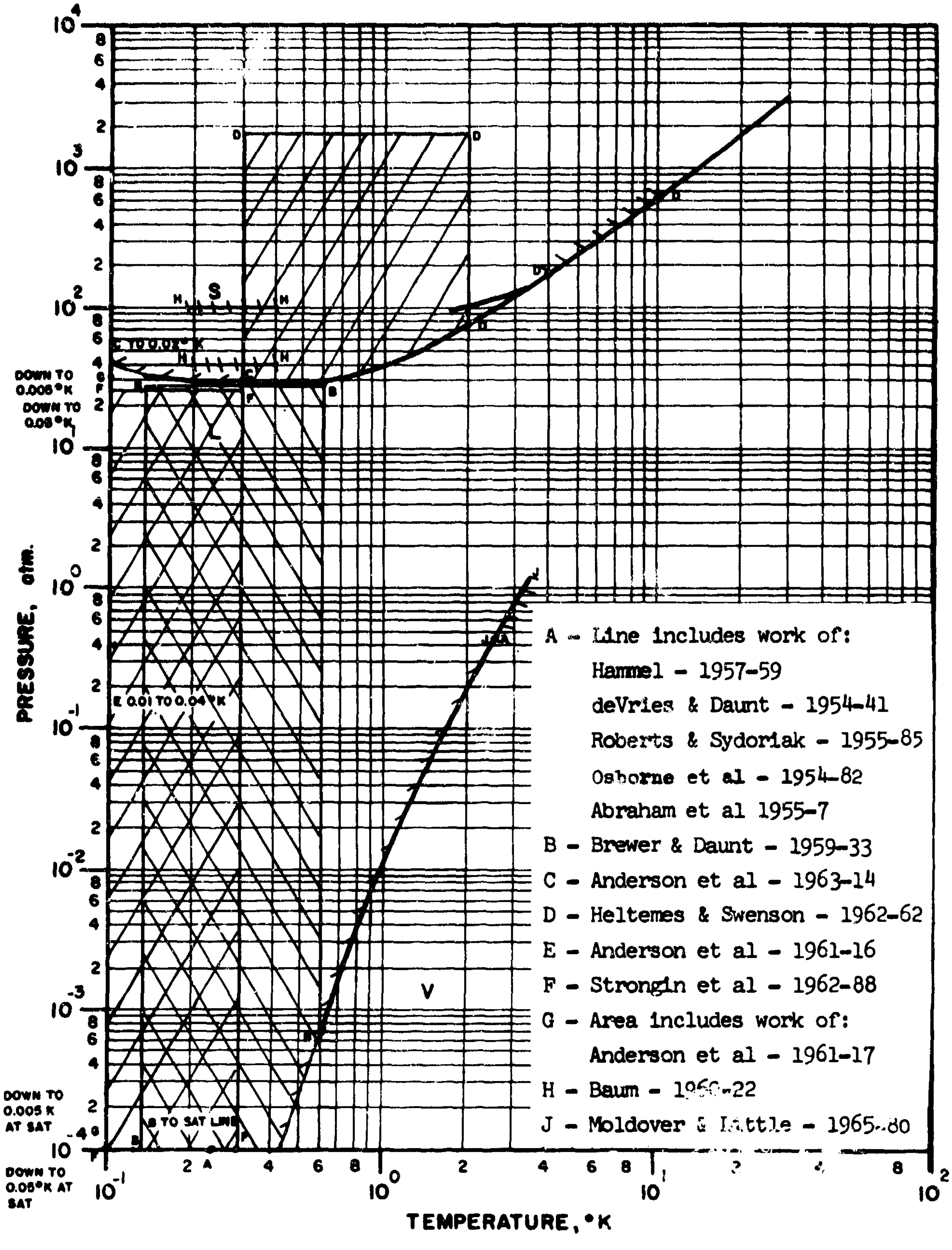


Figure 6. Available Experimental Heat Capacity Data for Helium-3.

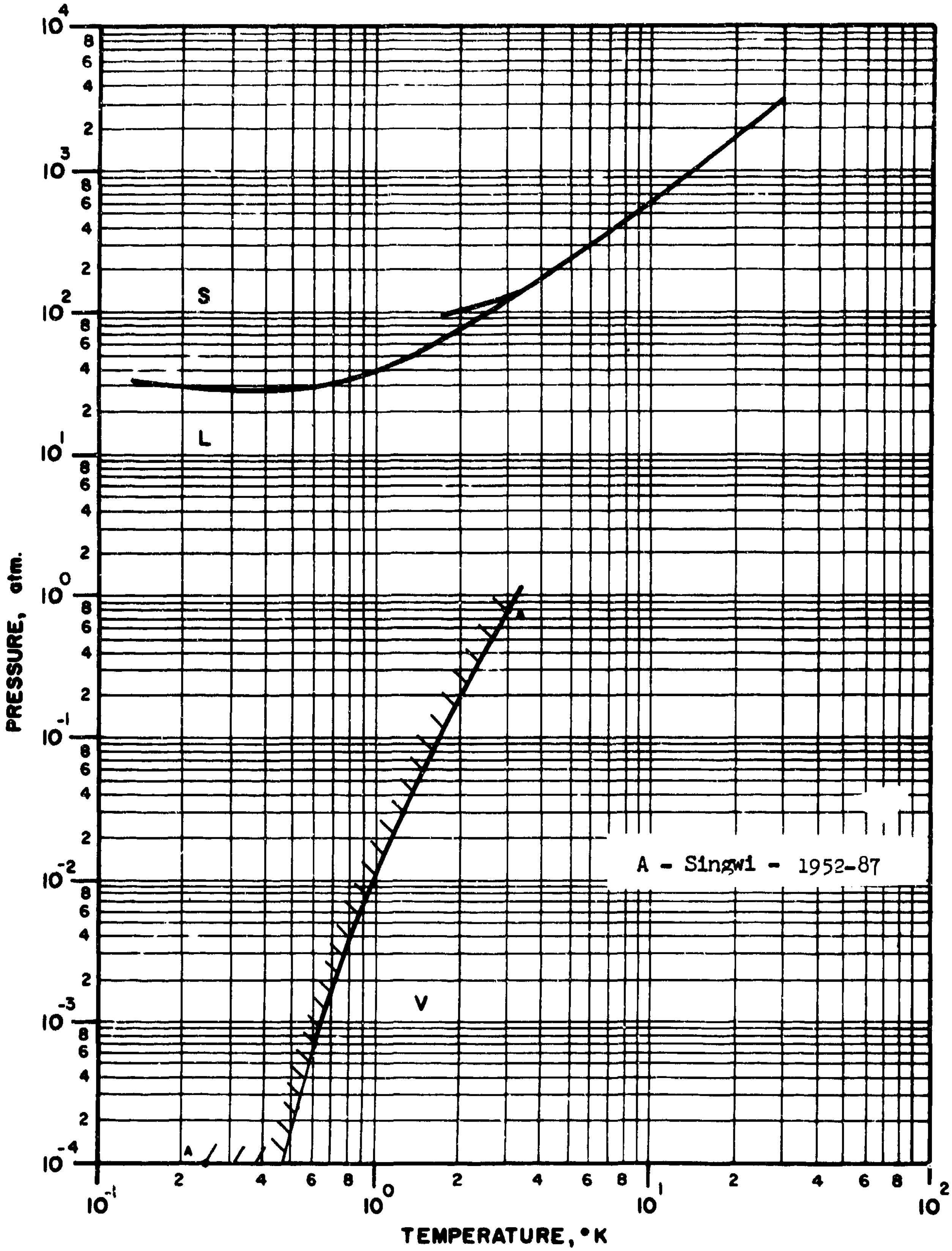


Figure 7. Available Calculated Heat Capacity Data for Helium-3

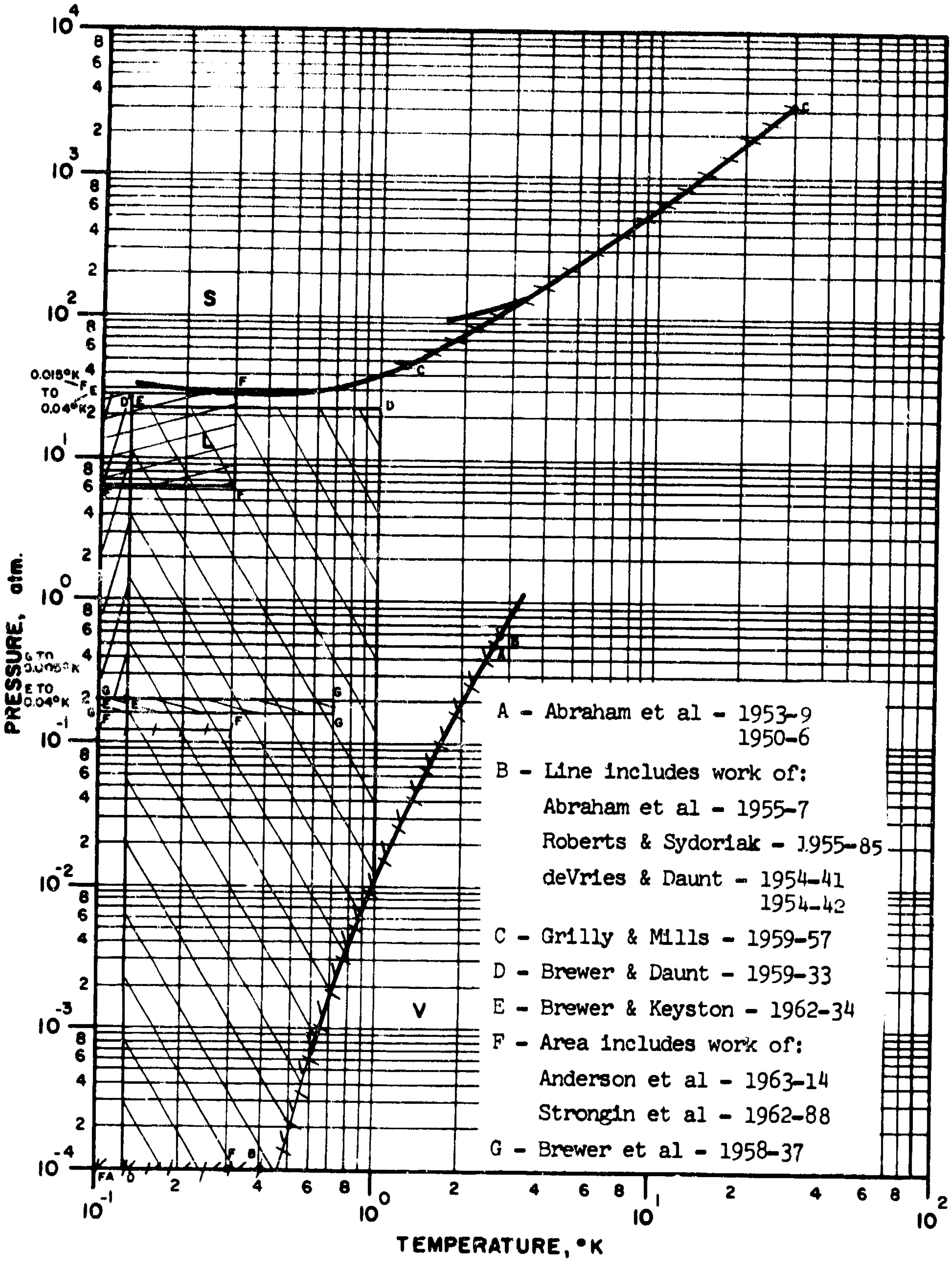


Figure 8. Available Entropy Data for Helium-3

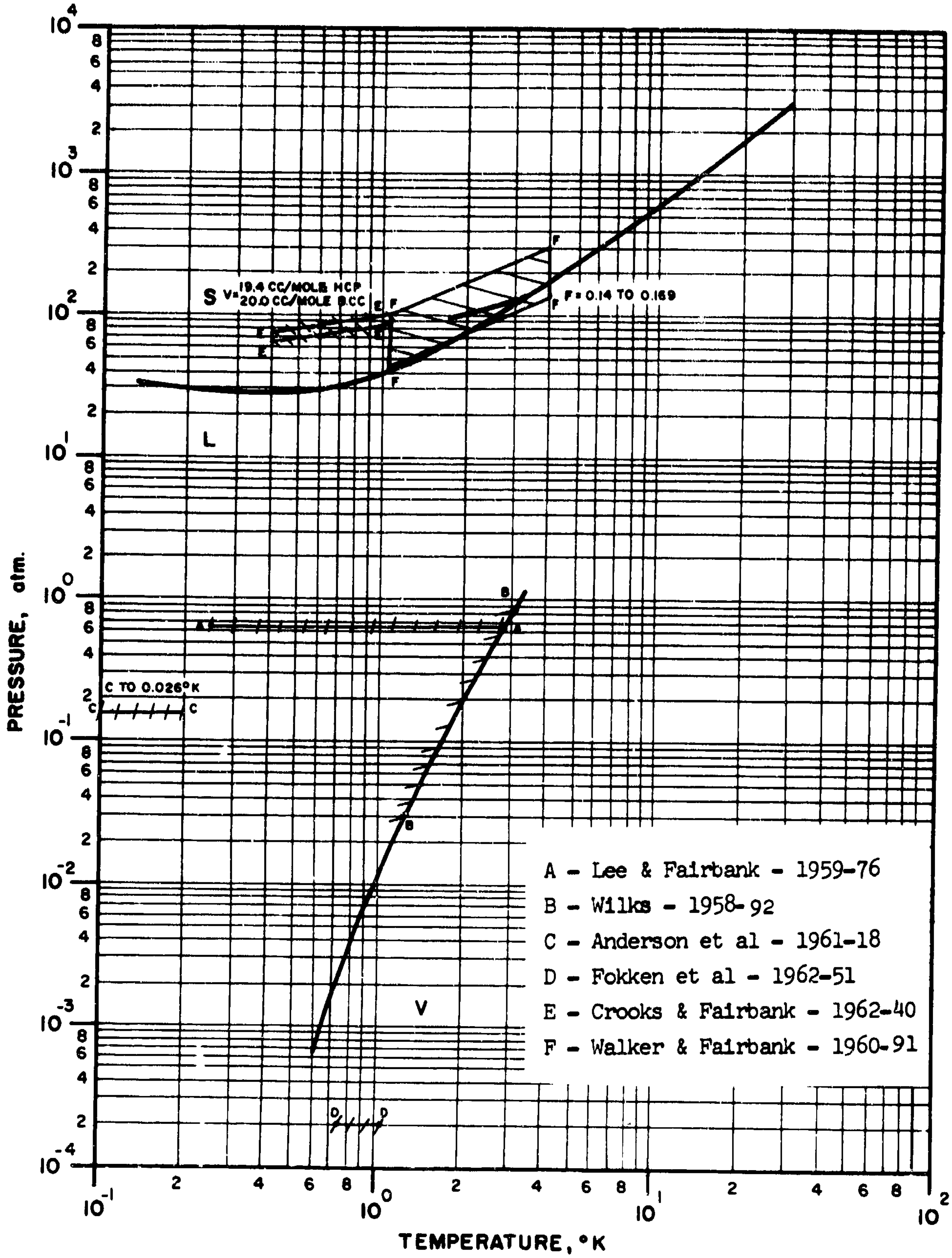


Figure 9. Available Experimental Thermal Conductivity Data for Helium-3

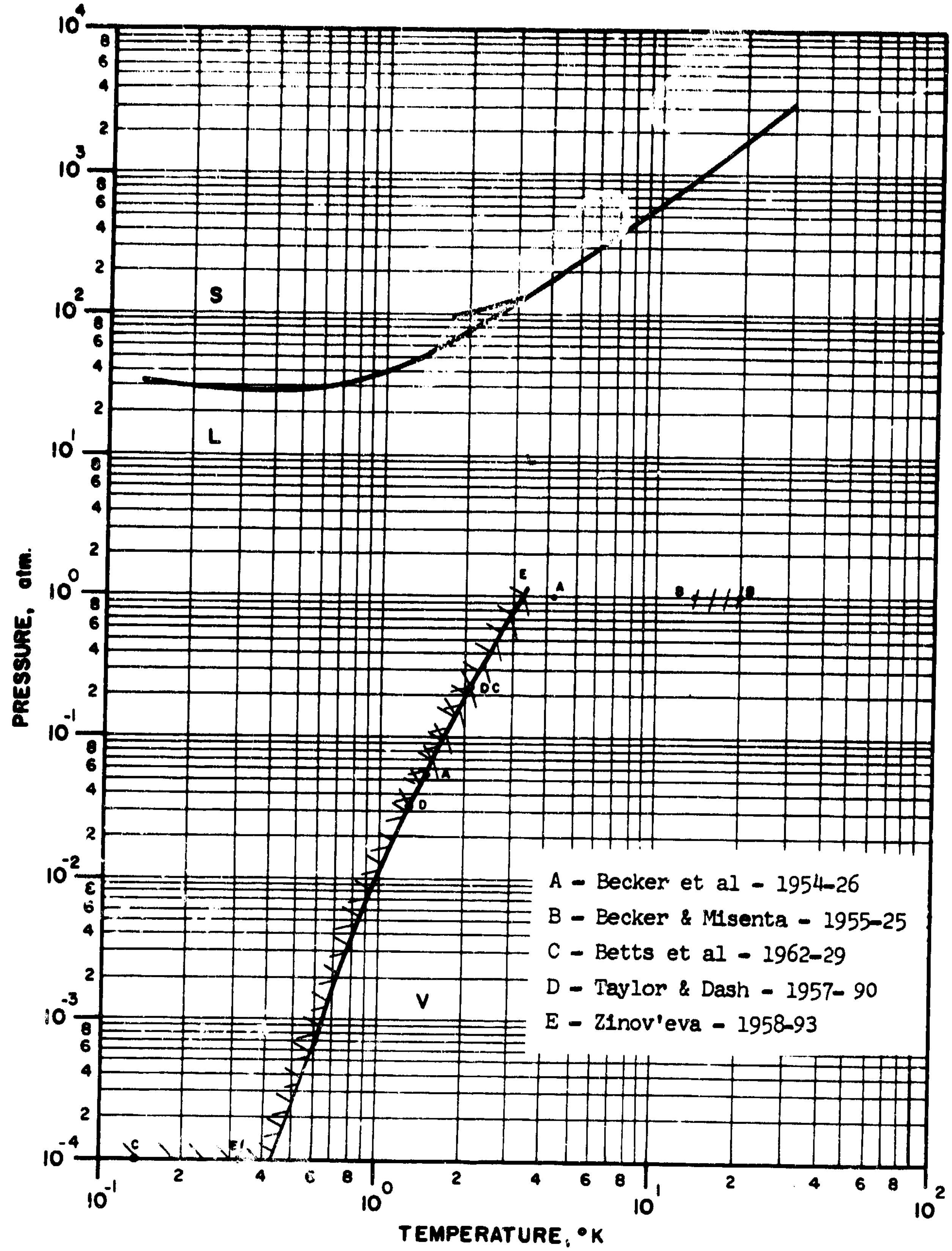


Figure 10. Available Experimental Viscosity Data for Helium-3

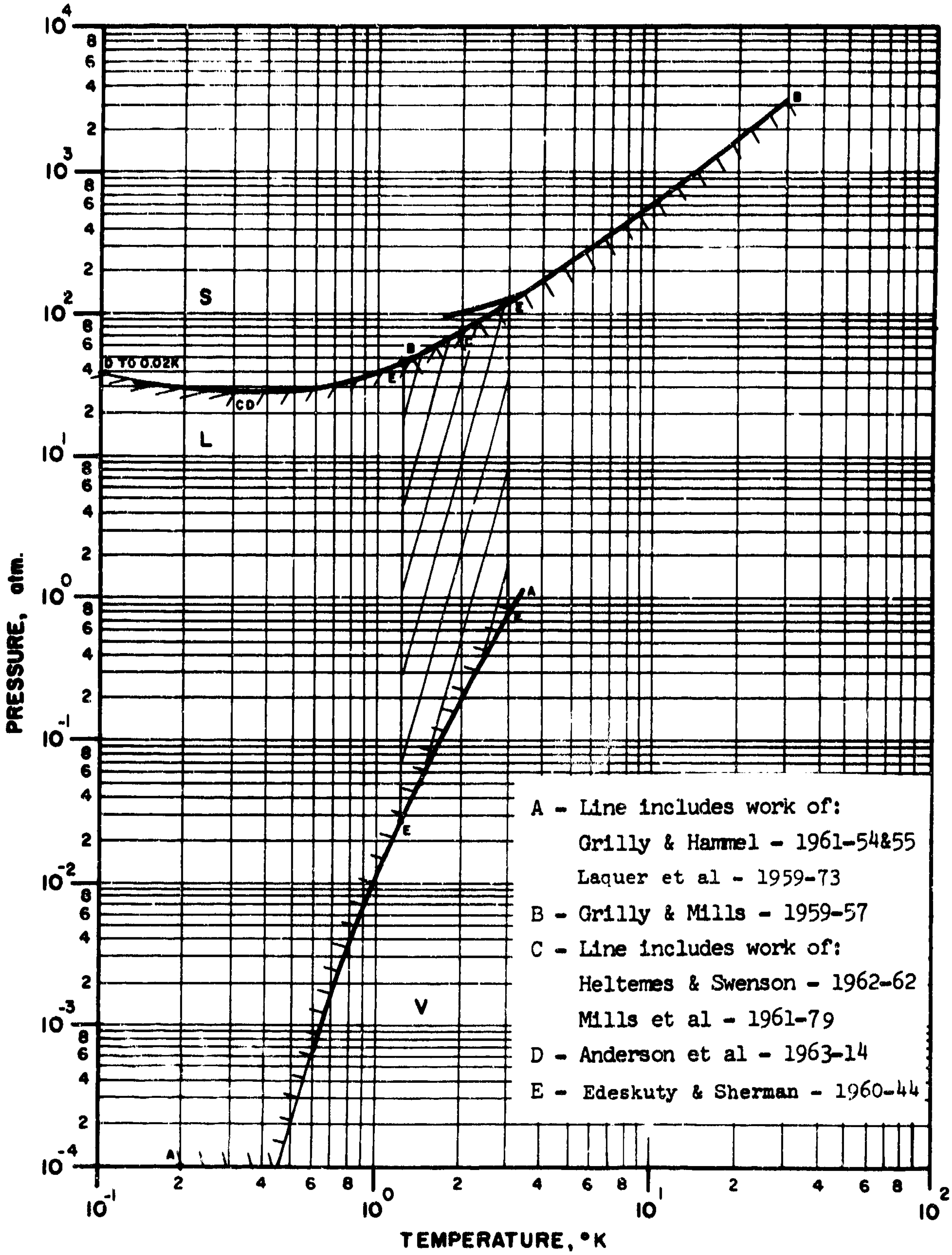


Figure 11. Available Compression Coefficient Data for Helium-3

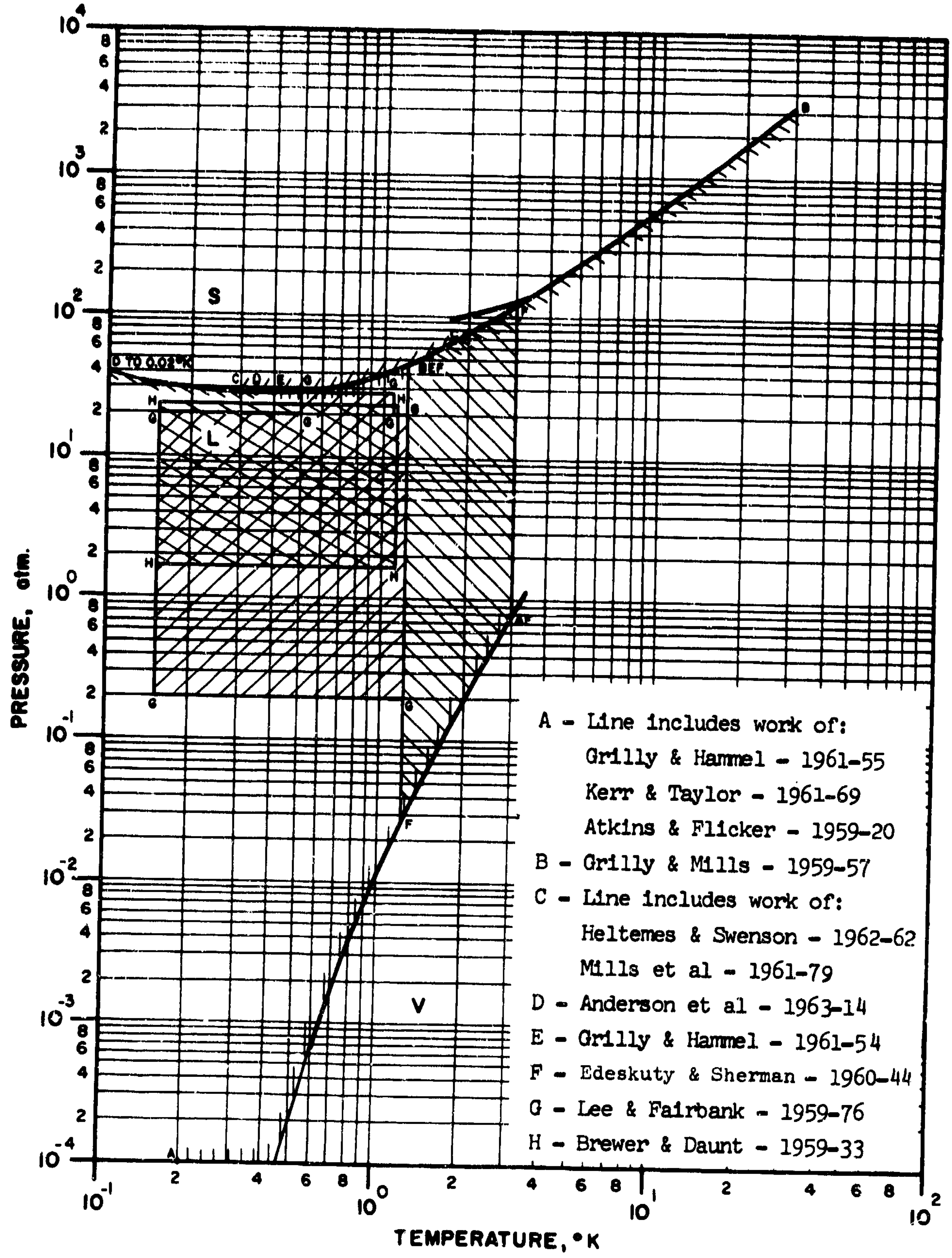


Figure 12. Available Expansion Coefficient Data for Helium-3

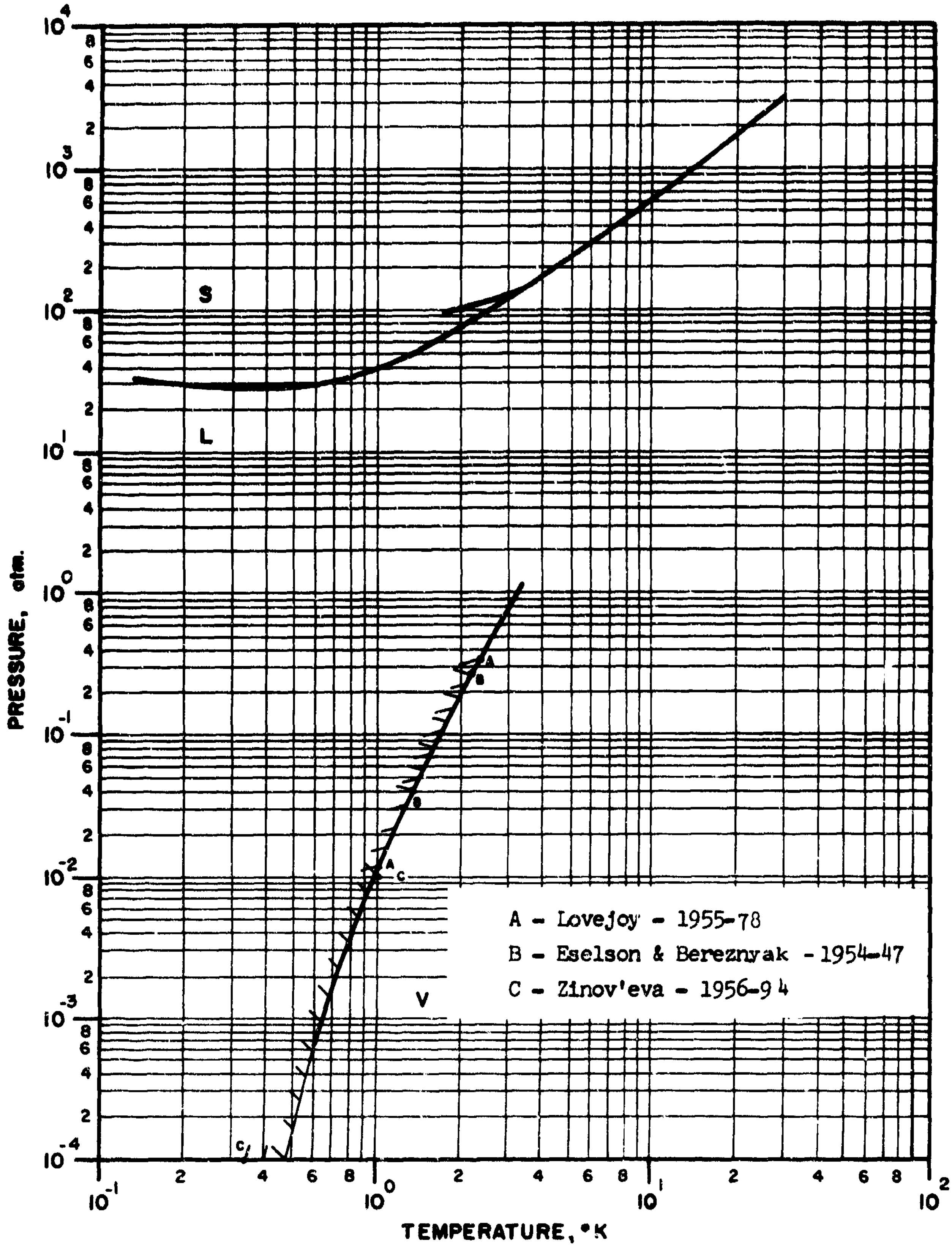


Figure 13. Available Experimental Surface Tension Data for Helium-3

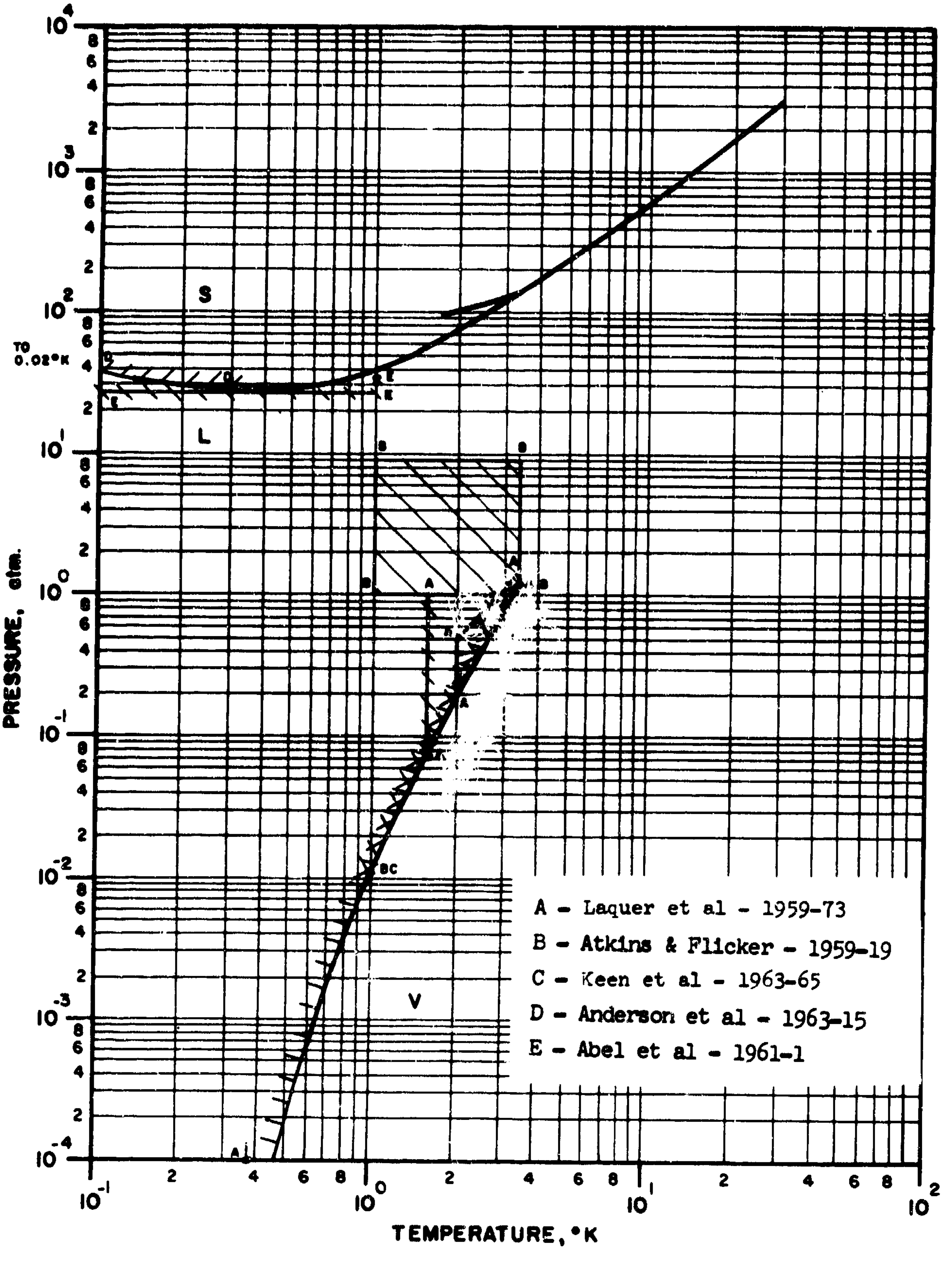


Figure 14. Available Experimental Velocity of Sound Data for Helium-3

APPENDIX II

TABLES OF THE THERMODYNAMIC AND TRANSPORT PROPERTIES OF HE^3 FROM $1^{o}K$ to $100^{o}K$

P = 1.00 ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./DEG.K	VISCOSITY μPOISES	TH.COND J./CM./SEC./DEG.X100000
1.000	11.853	-5.161	-6.352	2.252		
2.000	12.387	-2.771	-4.027	4.101		
3.000	12.387	13.147	11.392	8.410		
4.000	79.253	22.689	14.294	12.651		11.335
5.000	115.059	30.980	19.115	14.514		12.476
6.000	146.545	38.318	23.339	15.942		13.504
7.000	190.452	45.553	27.575	17.271		14.466
8.000	217.659	52.697	31.537	18.169		15.571
9.000	244.867	59.752	35.329	18.959		16.629
10.000	272.074	66.816	39.396	19.631		17.544
11.000	299.281	73.892	44.132	20.346		18.522
12.000	326.488	80.944	48.379	20.945		19.559
13.000	353.696	87.909	52.533	21.501	17.219	20.485
14.000	380.903	95.046	56.730	22.015	21.907	21.377
15.000	408.111	102.083	60.907	22.494	23.257	22.246
16.000	435.318	109.109	65.233	22.942	24.487	23.095
17.000	462.525	116.125	69.406	23.364	25.765	23.925
18.000	489.733	123.131	73.607	23.761	26.943	24.739
19.000	516.940	130.128	77.804	24.137	28.061	25.539
20.000	544.147	137.115	81.998	24.493	29.138	26.322
21.000	571.355	144.205	86.353	25.243	30.181	27.094
22.000	598.562	151.136	90.505	25.554	31.198	27.853
23.000	625.770	158.064	94.656	25.871	32.192	28.612
24.000	652.977	164.989	98.805	26.155	33.165	29.346
25.000	680.184	171.913	102.954	26.447	34.119	30.069
26.000	707.392	178.834	107.102	26.718	35.057	30.788
27.000	734.599	185.753	111.249	26.979	35.980	31.499
28.000	761.807	192.671	115.396	27.233	36.888	32.202
29.000	789.014	199.587	119.542	27.472	37.783	32.898
30.000	816.221	206.502	123.687	27.716	38.666	33.586
31.000	843.429	213.416	127.832	27.932	39.538	34.263
32.000	870.635	220.329	131.975	28.152	40.398	34.943
33.000	897.844	227.240	136.120	28.364	41.249	35.612
34.000	925.051	234.150	140.264	28.570	42.090	36.274
35.000	952.258	241.060	144.407	28.775	42.922	36.932
36.000	979.466	247.969	148.550	28.965	43.745	37.583
37.000	1006.673	254.877	152.692	29.154	44.559	38.230
38.000	1033.880	261.784	156.834	29.338	45.367	38.871
39.000	1061.088	268.690	160.976	29.518	46.167	39.503

P= 1.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM./SEC/ DEG.X100000
40.000	1088.295	275.564	165.089	29.576	46.888	40.140
42.000	1142.710	289.376	173.372	29.912	48.455	41.390
44.000	1197.125	303.185	181.654	30.233	49.997	42.624
46.000	1251.540	316.991	189.935	30.540	51.515	43.841
48.000	1305.955	330.797	198.215	30.834	53.010	45.044
50.000	1360.368	344.600	206.495	31.116	54.485	46.232
52.000	1414.784	358.403	214.774	31.386	55.940	47.406
54.000	1469.198	372.204	223.052	31.647	57.375	48.567
56.000	1523.612	386.004	231.330	31.898	58.793	49.716
58.000	1578.029	399.803	239.608	32.140	60.194	50.853
60.000	1632.442	413.601	247.885	32.374	61.578	51.978
62.000	1686.858	427.398	256.161	32.600	62.946	53.092
64.000	1741.272	441.195	264.437	32.819	64.298	54.195
66.000	1795.687	454.990	272.713	33.032	65.637	55.288
68.000	1850.102	468.785	280.989	33.238	66.961	56.371
70.000	1904.516	482.580	289.264	33.438	68.271	57.444
72.000	1958.931	496.374	297.539	33.632	69.568	58.507
74.000	2013.345	510.167	305.814	33.821	70.852	59.561
76.000	2067.761	523.960	314.089	34.005	72.124	60.606
78.000	2122.175	537.753	322.363	34.184	73.385	61.642
80.000	2176.591	551.545	330.637	34.359	74.634	62.670
82.000	2231.005	565.336	338.911	34.529	75.871	63.689
84.000	2285.420	579.128	347.185	34.695	77.099	64.701
86.000	2339.835	592.919	355.459	34.858	78.316	65.704
88.000	2394.250	606.710	363.733	35.016	79.523	66.699
90.000	2448.665	620.500	372.006	35.171	80.721	67.687
92.000	2503.080	634.290	380.279	35.323	81.911	68.667
94.000	2557.494	648.080	388.552	35.471	83.092	69.640
96.000	2611.908	661.870	396.826	35.616	84.264	70.606
98.000	2666.324	675.659	405.099	35.759	85.429	71.565
100.000	2720.738	689.448	413.371	35.898	86.587	72.516

P= 2.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./DEG.K	VISCOSITY µPOISES	TH.COND J./CM./SEC/DEG.X100000
1.000	11.515	-3.993	-6.327	2.235		
2.000	11.902	-1.701	-4.113	4.111		
3.000	11.900	14.217	11.306	9.320		
4.000	18.269	8.013	4.310	7.874		24.191
5.000	48.305	26.910	17.069	12.209		16.060
6.000	63.571	34.003	21.641	13.643		16.126
7.000	80.964	42.623	25.917	14.831		16.519
8.000	97.289	50.017	30.112	15.895		17.194
9.000	113.015	57.348	34.325	16.773		17.972
10.000	128.336	64.650	38.565	17.551		18.793
11.000	149.441	72.081	42.937	18.373		19.544
12.000	163.244	79.291	47.185	18.975		20.406
13.000	176.848	86.492	51.448	19.532	17.497	21.253
14.000	190.452	93.679	55.719	20.049	21.272	22.085
15.000	204.055	100.849	59.993	20.532	23.285	22.903
16.000	217.659	107.999	64.265	20.934	24.766	23.707
17.000	231.263	115.131	68.533	21.409	26.039	24.498
18.000	244.867	122.245	72.795	21.809	27.209	25.277
19.000	258.470	129.341	77.052	22.198	28.318	26.045
20.000	272.074	136.426	81.301	22.548	29.384	26.831
21.000	285.677	143.703	85.565	23.310	30.418	27.548
22.000	299.281	150.670	90.032	23.632	31.425	28.285
23.000	312.885	157.632	94.198	23.940	32.410	29.013
24.000	326.489	164.588	98.361	24.234	33.374	29.733
25.000	340.092	171.541	102.523	24.517	34.321	30.444
26.000	353.696	178.490	106.683	24.788	35.251	31.148
27.000	367.300	185.435	110.842	25.050	36.166	31.845
28.000	380.903	192.377	114.999	25.301	37.067	32.534
29.000	394.507	199.316	119.155	25.544	37.955	33.217
30.000	408.111	206.253	123.310	25.779	38.832	33.894
31.000	421.714	213.187	127.464	26.006	39.697	34.564
32.000	435.318	220.119	131.617	26.225	40.551	35.229
33.000	448.922	227.049	135.770	26.438	41.396	35.888
34.000	462.525	233.977	139.921	26.645	42.232	36.542
35.000	476.129	240.904	144.072	26.845	43.058	37.191
36.000	489.733	247.828	148.222	27.040	43.876	37.835
37.000	503.336	254.752	152.371	27.230	44.686	38.474
38.000	516.940	261.673	156.520	27.414	45.489	39.108
39.000	530.544	268.594	160.668	27.594	46.284	39.738

P= 2.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	544.148	275.469	164.780	27.652	47.000	40.363
42.000	571.355	289.307	173.075	27.989	48.560	41.602
44.000	598.563	303.140	181.368	28.311	50.094	42.824
46.000	625.770	316.969	189.660	28.618	51.606	44.032
48.000	652.977	330.795	197.950	28.912	53.095	45.225
50.000	680.185	344.618	206.238	29.194	54.564	46.404
52.000	707.392	358.438	214.526	29.466	56.014	47.571
54.000	734.599	372.256	222.812	29.726	57.445	48.725
56.000	761.807	386.071	231.097	29.978	58.859	49.867
58.000	789.014	399.885	239.382	30.220	60.255	50.997
60.000	816.221	413.697	247.665	30.454	61.636	52.117
62.000	843.429	427.507	255.948	30.681	63.001	53.225
64.000	870.636	441.315	264.230	30.900	64.351	54.323
66.000	897.844	455.123	272.511	31.113	65.687	55.411
68.000	925.051	468.929	280.792	31.319	67.008	56.489
70.000	952.258	482.733	289.073	31.519	68.316	57.557
72.000	979.466	496.537	297.353	31.714	69.612	58.617
74.000	1006.673	510.340	305.632	31.903	70.894	59.667
76.000	1033.880	524.142	313.911	32.087	72.165	60.708
78.000	1061.088	537.943	322.189	32.266	73.424	61.741
80.000	1088.295	551.743	330.467	32.441	74.672	62.765
82.000	1115.502	565.543	338.745	32.612	75.909	63.781
84.000	1142.710	579.341	347.023	32.778	77.135	64.789
86.000	1169.917	593.139	355.300	32.941	78.352	65.789
88.000	1197.125	606.937	363.577	33.099	79.559	66.781
90.000	1224.332	620.734	371.854	33.254	80.757	67.766
92.000	1251.540	634.530	380.130	33.406	81.946	68.744
94.000	1278.747	648.326	388.406	33.555	83.126	69.714
96.000	1305.955	662.122	396.682	33.700	84.299	70.677
98.000	1333.162	675.917	404.957	33.842	85.463	71.633
100.000	1360.368	689.711	413.232	33.982	86.621	72.583

P= 3.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	11.240	-2.852	-6.269	2.223		
2.000	11.542	-0.635	-4.143	4.051		
3.000	12.424	1.268	-2.509	5.246		
4.000	14.738	6.901	2.421	7.154		27.724
5.000	23.143	17.264	10.229	9.359		22.734
6.000	39.499	32.181	20.074	12.314		19.016
7.000	51.375	40.125	24.482	13.589		18.654
8.000	61.052	47.561	28.613	14.552		19.011
9.000	72.343	55.131	32.893	15.477		19.441
10.000	83.174	62.640	37.202	16.235		20.030
11.000	93.677	70.111	41.537	17.009		20.699
12.000	103.933	77.544	45.891	17.662		21.410
13.000	113.957	84.941	50.253	18.258	17.809	22.142
14.000	126.968	92.303	54.630	18.877	21.539	22.828
15.000	136.037	99.684	59.024	19.363	23.563	23.592
16.000	145.106	106.951	63.357	19.819	25.045	24.349
17.000	154.175	114.192	67.686	20.247	26.312	25.099
18.000	163.244	121.407	72.007	20.651	27.474	25.841
19.000	172.313	128.596	76.320	21.033	28.573	26.577
20.000	181.382	135.763	80.623	21.335	29.629	27.304
21.000	190.452	143.238	85.387	22.170	30.653	28.025
22.000	199.521	150.238	89.569	22.493	31.651	28.738
23.000	208.590	157.231	93.749	22.801	32.626	29.445
24.000	217.659	164.217	97.925	23.097	33.582	30.145
25.000	226.728	171.197	102.099	23.380	34.520	30.838
26.000	235.797	178.171	106.271	23.6[illegible]	35.442	31.526
27.000	244.866	185.141	110.440	23.91[illegible]	36.349	32.207
28.000	253.936	192.106	114.608	24.166	37.243	32.882
29.000	263.005	199.067	118.774	24.409	38.125	33.552
30.000	272.074	206.024	122.938	24.644	38.994	34.217
31.000	281.143	212.978	127.101	24.372	39.853	34.876
32.000	290.212	219.929	131.263	25.092	40.702	35.530
33.000	299.281	226.876	135.423	25.305	41.541	36.179
34.000	308.350	233.821	139.582	25.512	42.370	36.824
35.000	317.419	240.763	143.740	25.713	43.192	37.464
36.000	326.489	247.704	147.307	25.908	44.005	38.099
37.000	335.558	254.641	152.053	26.096	44.810	38.730
38.000	344.627	261.577	156.209	26.283	45.608	39.357
39.000	353.696	268.511	160.363	26.463	46.399	39.980

P= 3.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM./SEC/ DEG.X100000
40.000	362.765	275.387	164.473	26.521	47.110	40.599
42.000	380.903	289.250	172.780	26.859	48.662	41.825
44.000	399.042	303.106	181.084	27.181	50.190	43.037
46.000	417.180	316.957	189.385	27.489	51.694	44.234
48.000	435.318	330.803	197.686	27.784	53.178	45.418
50.000	453.456	344.644	205.983	28.066	54.642	46.589
52.000	471.594	358.481	214.279	28.338	56.087	47.748
54.000	489.733	372.316	222.573	28.599	57.514	48.895
56.000	507.871	386.146	230.866	28.850	58.923	50.030
58.000	526.010	399.974	239.157	29.093	60.316	51.154
60.000	544.148	413.799	247.447	29.328	61.693	52.268
62.000	562.286	427.622	255.736	29.554	63.055	53.371
64.000	580.424	441.443	264.024	29.774	64.403	54.464
66.000	598.563	455.261	272.311	29.987	65.736	55.547
68.000	616.701	469.078	280.597	30.193	67.055	56.620
70.000	634.839	482.893	288.882	30.394	68.361	57.685
72.000	652.977	496.706	297.167	30.588	69.655	58.740
74.000	671.115	510.518	305.450	30.778	70.936	59.786
76.000	689.254	524.329	313.733	30.962	72.206	60.824
78.000	707.392	538.138	322.016	31.142	73.463	61.853
80.000	725.530	551.946	330.298	31.317	74.710	62.874
82.000	743.668	565.753	338.580	31.487	75.946	63.887
84.000	761.807	579.559	346.861	31.654	77.172	64.892
86.000	779.945	593.365	355.141	31.817	78.388	65.889
88.000	798.083	607.169	363.421	31.975	79.595	66.879
90.000	816.221	620.972	371.701	32.131	80.792	67.861
92.000	834.360	634.774	379.980	32.283	81.980	68.836
94.000	852.498	648.576	388.260	32.431	83.161	69.804
96.000	870.636	662.377	396.538	32.577	84.333	70.765
98.000	888.775	676.178	404.816	32.719	85.498	71.719
100.000	906.913	689.978	413.094	32.859	86.656	72.667

P= 4.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	11.001	-1.734	-6.193	2.214		
2.000	11.240	0.426	-4.129	4.002		
3.000	11.923	2.335	-2.498	5.121		
4.000	13.299	6.750	1.360	6.816		29.622
5.000	17.848	14.893	7.659	8.606		26.342
6.000	27.717	29.804	18.550	11.279		22.222
7.000	36.275	37.876	23.087	12.578		21.096
8.000	44.952	45.597	27.344	13.651		20.780
9.000	52.230	53.081	31.513	14.508		21.041
10.000	60.778	60.768	35.884	15.350		21.355
11.000	68.994	68.406	40.287	16.096		21.834
12.000	76.960	75.999	44.712	16.768		22.406
13.000	84.735	83.546	49.146	17.379	18.121	23.031
14.000	92.356	91.045	53.580	17.939	21.846	23.698
15.000	102.028	98.591	58.089	18.519	23.843	24.301
16.000	108.829	105.963	62.479	18.978	25.325	25.010
17.000	115.631	113.305	66.865	19.410	26.586	25.718
18.000	122.433	120.615	71.242	19.817	27.738	26.424
19.000	129.235	127.894	75.608	20.202	28.327	27.126
20.000	136.037	135.142	79.963	20.568	29.873	27.824
21.000	142.839	142.807	84.920	21.354	30.887	28.517
22.000	149.641	149.838	89.116	21.678	31.874	29.206
23.000	156.442	156.960	93.308	21.987	32.840	29.891
24.000	163.244	163.873	97.495	22.233	33.787	30.572
25.000	170.046	170.879	101.682	22.567	34.716	31.245
26.000	176.848	177.878	105.864	22.840	35.630	31.916
27.000	183.650	184.870	110.044	23.102	36.530	32.581
28.000	190.452	191.857	114.222	23.355	37.417	33.242
29.000	197.253	198.838	118.397	23.599	38.291	33.898
30.000	204.055	205.815	122.571	23.834	39.154	34.550
31.000	210.857	212.788	126.742	24.062	40.007	35.198
32.000	217.659	219.756	130.912	24.283	40.849	35.841
33.000	224.461	226.720	135.080	24.497	41.682	36.480
34.000	231.263	233.681	139.247	24.704	42.506	37.115
35.000	238.065	240.639	143.412	24.905	43.322	37.745
36.000	244.867	247.594	147.576	25.101	44.130	38.372
37.000	251.668	254.546	151.739	25.291	44.931	38.996
38.000	258.470	261.495	155.901	25.476	45.724	39.615
39.000	265.272	268.442	160.061	25.656	46.510	40.230

P= 4.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	272.074	275.318	164.169	25.715	47.218	40.843
42.000	285.677	289.205	172.488	26.053	48.762	42.056
44.000	299.281	303.083	180.803	26.376	50.283	43.256
46.000	312.885	316.955	189.115	26.684	51.781	44.443
48.000	326.489	330.820	197.424	26.979	53.259	45.618
50.000	340.092	344.680	205.730	27.262	54.718	46.780
52.000	353.696	358.534	214.034	27.534	56.158	47.931
54.000	367.300	372.384	222.336	27.796	57.580	49.070
56.000	380.903	386.229	230.635	28.048	58.986	50.199
58.000	394.507	400.071	238.933	28.291	60.376	51.316
60.000	408.111	413.909	247.230	28.526	61.750	52.424
62.000	421.714	427.744	255.525	28.753	63.109	53.522
64.000	435.318	441.577	263.818	28.973	64.454	54.609
66.000	448.922	455.406	272.111	29.186	65.784	55.688
68.000	462.525	469.233	280.402	29.392	67.102	56.757
70.000	476.129	483.058	288.692	29.593	68.406	57.817
72.000	489.733	496.881	296.981	29.788	69.698	58.868
74.000	503.337	510.702	305.269	29.978	70.978	59.910
76.000	516.940	524.521	313.557	30.162	72.246	60.944
78.000	530.544	538.338	321.843	30.342	73.503	61.970
80.000	544.148	552.154	330.129	30.517	74.749	62.988
82.000	557.751	565.969	338.414	30.688	75.984	63.998
84.000	571.355	579.782	346.699	30.854	77.209	65.000
86.000	584.959	593.594	354.983	31.017	78.424	65.994
88.000	598.563	607.404	363.266	31.176	79.630	66.981
90.000	612.166	621.214	371.549	31.332	80.827	67.961
92.000	625.770	635.022	379.831	31.484	82.016	68.934
94.000	639.374	648.830	388.113	31.632	83.196	69.899
96.000	652.977	662.636	396.395	31.778	84.368	70.858
98.000	666.581	676.442	404.676	31.920	85.533	71.810
100.000	680.185	690.247	412.956	32.060	86.690	72.755

P= 5.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./DEG.K	VISCOSITY μPOISES	TH.COND J./CM./SEC./DEG.X10[illegible]
1.000	10.756	-0.631	-6.100	2.202		
2.000	10.981	1.476	-4.085	3.965		
3.000	11.542	3.480	-2.358	5.024		
4.000	12.487	6.940	0.514	6.581		30.855
5.000	15.531	13.969	5.101	8.146		28.604
6.000	20.265	22.867	12.600	9.641		26.240
7.000	27.732	36.120	21.847	11.775		23.521
8.000	34.829	43.823	26.122	12.832		22.725
9.000	41.630	51.484	30.377	13.819		22.512
10.000	47.539	59.074	34.635	14.506		22.737
11.000	54.339	66.842	39.094	15.368		23.010
12.000	60.903	74.569	43.581	16.057		23.432
13.000	67.282	82.247	48.082	16.631	18.454	23.944
14.000	73.514	89.872	52.584	17.252	22.141	24.511
15.000	79.627	97.444	57.079	17.779	24.165	25.115
16.000	87.064	105.037	61.631	18.316	25.609	25.685
17.000	92.505	112.472	66.070	18.751	26.862	26.356
18.000	97.947	119.871	70.490	19.162	28.004	27.018
19.000	103.388	127.233	74.917	19.550	29.082	27.685
20.000	108.829	134.559	79.322	19.918	30.115	28.354
21.000	114.271	142.410	84.463	20.715	31.119	29.020
22.000	119.712	149.470	88.671	21.041	32.097	29.685
23.000	125.154	156.518	92.875	21.351	33.053	30.347
24.000	130.595	163.557	97.075	21.645	33.990	31.006
25.000	136.037	170.586	101.271	21.932	34.911	31.662
26.000	141.478	177.608	105.465	22.206	35.817	32.314
27.000	146.920	184.622	109.654	22.469	36.709	32.964
28.000	152.361	191.630	113.842	22.722	37.588	33.610
29.000	157.803	198.631	118.026	22.966	38.455	34.252
30.000	163.244	205.626	122.208	23.202	39.312	34.891
31.000	168.686	212.616	126.388	23.431	40.158	35.527
32.000	174.127	219.601	130.566	23.652	40.994	36.159
33.000	179.569	226.582	134.742	23.866	41.821	36.787
34.000	185.010	233.558	138.915	24.074	42.640	37.412
35.000	190.452	240.530	143.088	24.275	43.450	38.034
36.000	195.893	247.499	147.258	24.471	44.253	38.652
37.000	201.335	254.464	151.428	24.662	45.049	39.267
38.000	206.776	261.427	155.595	24.847	45.837	39.878
39.000	212.218	268.386	159.762	25.028	46.619	40.487

P= 5.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	217.659	275.261	163.867	25.087	47.323	41.092
42.000	228.542	289.171	172.198	25.426	48.860	42.292
44.000	239.425	303.072	180.524	25.749	50.374	43.481
46.000	250.308	316.964	188.845	26.058	51.866	44.657
48.000	261.191	330.847	197.163	26.353	53.339	45.822
50.000	272.074	344.724	205.478	26.637	54.792	46.975
52.000	282.957	358.595	213.790	26.909	56.228	48.118
54.000	293.840	372.460	222.099	27.171	57.646	49.250
56.000	304.723	386.320	230.406	27.423	59.048	50.371
58.000	315.605	400.175	238.711	27.666	60.434	51.483
60.000	326.489	414.026	247.014	27.902	61.805	52.584
62.000	337.371	427.873	255.315	28.129	63.162	53.676
64.000	348.254	441.717	263.614	28.349	64.504	54.758
66.000	359.137	455.557	271.911	28.562	65.833	55.832
68.000	370.020	469.394	280.208	28.769	67.148	56.896
70.000	380.903	483.229	288.502	28.970	68.451	57.952
72.000	391.786	497.061	296.796	29.165	69.741	58.999
74.000	402.669	510.890	305.089	29.355	71.019	60.038
76.000	413.552	524.718	313.380	29.540	72.286	61.068
78.000	424.435	538.543	321.671	29.720	73.542	62.090
80.000	435.318	552.367	329.961	29.895	74.787	63.105
82.000	446.201	566.188	338.250	30.066	76.021	64.112
84.000	457.084	580.008	346.537	30.233	77.246	65.111
86.000	467.967	593.827	354.825	30.396	78.461	66.102
88.000	478.850	607.644	363.111	30.555	79.666	67.087
90.000	489.733	621.460	371.397	30.710	80.863	68.064
92.000	500.616	635.274	379.682	30.863	82.051	69.034
94.000	511.499	649.087	387.967	31.011	83.231	69.997
96.000	522.382	662.890	396.251	31.157	84.403	70.954
98.000	533.265	675.710	404.535	31.300	85.568	71.904
100.000	544.148	690.520	412.818	31.440	86.725	72.847

P= 6.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	10.613	0.448	-6.005	2.205		
2.000	10.773	2.513	-4.036	3.932		
3.000	11.247	3.934	-2.904	4.942		
4.000	11.979	7.681	0.398	6.415		31.695
5.000	14.058	13.476	4.907	7.748		30.322
6.000	17.633	21.728	11.008	9.217		28.094
7.000	22.447	31.120	17.474	10.533		26.087
8.000	28.438	42.455	25.061	12.256		24.643
9.000	34.109	50.035	29.269	13.198		24.103
10.000	39.696	57.742	33.609	14.037		23.990
11.000	44.720	65.439	37.973	14.760		24.204
12.000	50.316	73.266	42.509	15.464		24.473
13.000	55.742	81.052	47.066	16.101	18.814	24.869
14.000	61.031	88.786	51.628	16.683	22.456	25.345
15.000	66.207	96.464	56.184	17.218	24.473	25.875
16.000	71.292	104.083	60.728	17.713	25.930	26.441
17.000	77.088	111.693	65.301	18.205	27.142	26.991
18.000	81.622	119.174	69.780	18.619	28.272	27.621
19.000	86.157	126.614	74.247	19.010	29.337	28.255
20.000	90.691	134.014	78.698	19.381	30.360	28.893
21.000	95.226	142.046	84.015	20.191	31.351	29.532
22.000	99.760	149.131	88.235	20.516	32.318	30.171
23.000	104.295	156.205	92.450	20.827	33.264	30.810
24.000	108.830	163.267	96.661	21.124	34.192	31.448
25.000	113.364	170.319	100.868	21.410	35.104	32.085
26.000	117.899	177.362	105.071	21.684	36.001	32.720
27.000	122.433	184.396	109.270	21.947	36.885	33.354
28.000	126.968	191.423	113.467	22.201	37.757	33.984
29.000	131.502	198.443	117.660	22.446	38.617	34.613
30.000	136.037	205.455	121.850	22.683	39.467	35.239
31.000	140.572	212.462	126.038	22.912	40.306	35.862
32.000	145.106	219.463	130.224	23.133	41.136	36.483
33.000	149.641	226.459	134.407	23.348	41.958	37.101
34.000	154.175	233.450	138.588	23.556	42.771	37.716
35.000	158.710	240.437	142.767	23.758	43.576	38.328
36.000	163.244	247.419	146.944	23.954	44.373	38.937
37.000	167.779	254.397	151.119	24.145	45.164	39.543
38.000	172.314	261.372	155.293	24.331	45.948	40.147
39.000	176.848	268.343	159.465	24.512	46.725	40.748

P= 6.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./DEG.K	VISCOSITY μ POISES	TH.COND J./CM²/SEC/DEG.X 100000
40.000	181.393	275.217	163.569	24.571	47.426	41.346
42.000	190.452	289.149	171.910	24.910	48.956	42.533
44.000	199.521	303.071	180.246	25.234	50.463	43.710
46.000	208.590	316.982	188.578	25.543	51.949	44.875
48.000	217.659	330.884	196.905	25.839	53.417	46.030
50.000	226.728	344.778	205.228	26.123	54.865	47.174
52.000	235.797	358.664	213.548	26.396	56.296	48.308
54.000	244.867	372.544	221.865	26.658	57.711	49.433
56.000	253.936	386.418	230.178	26.911	59.109	50.547
58.000	263.005	400.286	238.490	27.155	60.492	51.652
60.000	272.074	414.150	246.799	27.390	61.860	52.747
62.000	281.143	428.008	255.106	27.618	63.214	53.833
64.000	290.212	441.863	263.410	27.838	64.554	54.910
66.000	299.281	455.714	271.713	28.052	65.880	55.979
68.000	308.351	469.561	280.014	28.259	67.194	57.038
70.000	317.419	483.405	288.314	28.460	68.495	58.090
72.000	326.489	497.246	296.612	28.655	69.784	59.132
74.000	335.558	511.084	304.909	28.845	71.061	60.167
76.000	344.627	524.920	313.205	29.030	72.327	61.194
78.000	353.696	538.753	321.499	29.210	73.581	62.213
80.000	362.765	552.584	329.793	29.386	74.825	63.224
82.000	371.834	566.413	338.085	29.557	76.059	64.227
84.000	380.904	580.239	346.376	29.724	77.283	65.224
86.000	389.973	594.064	354.667	29.887	78.497	66.212
88.000	399.042	607.888	362.957	30.046	79.702	67.194
90.000	408.111	621.709	371.246	30.202	80.899	68.169
92.000	417.180	635.530	379.534	30.354	82.086	69.136
94.000	426.249	649.348	387.822	30.503	83.266	70.097
96.000	435.318	663.166	396.108	30.649	84.438	71.051
98.000	444.387	676.982	404.395	30.792	85.603	71.999
100.000	453.457	690.797	412.680	30.932	86.761	72.940

P= 7.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µ POISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	10.448	2.506	-4.904	2.202		
2.000	10.590	3.540	-3.972	3.904		
3.000	10.991	4.857	-2.938	4.874		
4.000	11.621	8.492	0.249	6.289		32.325
5.000	13.163	13.464	4.128	7.466		31.614
6.000	15.879	21.127	9.864	8.865		29.791
7.000	19.579	29.819	15.932	10.108		27.936
8.000	23.763	38.788	21.933	11.219		26.663
9.000	28.963	48.885	28.296	12.678		25.652
10.000	33.735	56.524	32.583	13.518		25.326
11.000	38.472	64.308	37.016	14.281		25.299
12.000	42.862	72.101	41.501	14.956		25.517
13.000	47.584	79.968	46.103	15.603	19.210	25.737
14.000	52.183	87.792	50.717	16.194	22.794	26.183
15.000	56.678	95.560	55.328	16.737	24.795	26.639
16.000	61.088	103.269	59.927	17.240	26.236	27.143
17.000	66.075	110.966	64.558	17.737	27.428	27.637
18.000	69.962	118.524	69.084	18.154	28.544	28.230
19.000	73.849	126.037	73.597	18.548	29.596	28.830
20.000	77.735	133.506	78.093	18.922	30.605	29.437
21.000	81.622	141.714	83.578	19.742	31.584	30.049
22.000	85.509	148.823	87.808	20.069	32.540	30.663
23.000	89.396	155.919	92.033	20.380	33.475	31.280
24.000	93.282	163.003	96.254	20.678	34.393	31.897
25.000	97.169	170.076	100.471	20.964	35.296	32.515
26.000	101.056	177.139	104.683	21.239	36.184	33.132
27.000	104.943	184.192	108.892	21.503	37.060	33.749
28.000	110.131	191.252	113.127	21.792	37.910	34.333
29.000	114.124	198.288	117.329	22.039	38.763	34.947
30.000	118.112	205.316	121.528	22.278	39.606	35.560
31.000	122.094	212.338	125.724	22.508	40.439	36.171
32.000	126.071	219.353	129.917	22.731	41.263	36.780
33.000	130.044	226.362	134.107	22.946	42.079	37.388
34.000	134.013	233.366	138.294	23.156	42.887	37.993
35.000	137.978	240.365	142.480	23.358	43.687	38.596
36.000	141.939	247.359	146.663	23.555	44.480	39.197
37.000	145.897	254.348	150.844	23.747	45.266	39.796
38.000	149.852	261.333	155.023	23.933	46.046	40.392
39.000	153.805	268.315	159.201	24.115	46.819	40.986

P= 7.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µ POISES	TH.COND J./CM./SEC/ DEG.X100000
40.000	157.712	275.187	163.302	24.173	47.518	41.578
42.000	165.607	289.139	171.653	24.514	49.040	42.753
44.000	173.493	303.079	179.999	24.838	50.542	43.919
46.000	181.370	317.007	188.338	25.148	52.023	45.074
48.000	189.240	330.925	196.673	25.444	53.485	46.220
50.000	197.104	344.834	205.004	25.728	54.930	47.356
52.000	204.961	358.734	213.330	26.000	56.357	48.483
54.000	212.814	372.627	221.653	26.26[illegible]	57.768	49.600
56.000	220.661	386.513	229.973	26.51[illegible]	59.163	50.708
58.000	228.504	400.393	238.290	26.7[illegible]9	60.543	51.807
60.000	236.343	414.268	246.604	26.9[illegible]4	61.909	52.897
62.000	244.178	428.137	254.916	27.221	63.261	53.978
64.000	252.010	442.001	263.225	27.441	64.599	55.051
66.000	259.839	455.862	271.533	27.654	65.923	56.115
68.000	267.664	469.718	279.839	27.861	67.235	57.170
70.000	275.488	483.571	288.142	28.062	68.535	58.217
72.000	283.309	497.420	296.445	28.257	69.823	59.256
74.000	291.127	511.266	304.745	28.447	71.099	60.288
76.000	298.944	525.109	313.044	28.632	72.363	61.311
78.000	306.758	538.949	321.342	28.811	73.617	62.327
80.000	314.571	552.787	329.639	28.986	74.861	63.335
82.000	318.715	566.641	337.921	29.125	76.097	64.345
84.000	326.489	580.475	346.216	29.292	77.320	65.338
86.000	334.262	594.306	354.510	29.456	78.534	66.324
88.000	342.036	608.135	362.802	29.615	79.739	67.303
90.000	349.809	621.963	371.094	29.771	80.935	68.275
92.000	357.583	635.789	379.385	29.923	82.122	69.240
94.000	365.356	649.613	387.676	30.072	83.302	70.199
96.000	373.130	663.436	395.965	30.218	84.474	71.150
98.000	380.903	677.257	404.254	30.361	85.638	72.096
100.000	388.677	691.076	412.542	30.501	86.796	73.035

P= 8.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G / DEG.K	VISCOSITY μPOISES	TH.COND J./CM./SEC/ DEG.X100000
1.000	10.302	2.563	-5.788	2.195		
2.000	10.414	4.560	-3.882	3.882		
3.000	10.779	5.793	-2.944	4.819		
4.000	11.343	9.360	0.166	6.189		32.837
5.000	12.507	13.835	3.697	[illegible].264		32.618
6.000	14.682	20.920	9.019	8.543		31.151
7.000	17.656	29.034	14.722	9.774		29.478
8.000	21.267	37.995	20.756	10.884		28.079
9.000	24.917	46.657	26.459	11.833		27.295
10.000	29.409	55.531	31.674	13.070		26.622
11.000	33.540	63.274	36.081	13.835		26.444
12.000	37.365	71.077	40.564	14.513		26.549
13.000	41.542	78.998	45.198	15.168	19.650	26.719
14.000	45.607	86.890	49.353	15.767	23.159	27.016
15.000	49.581	94.735	54.512	16.317	25.135	27.401
16.000	53.477	102.521	59.160	16.825	26.553	27.845
17.000	57.816	110.292	63.340	17.325	27.723	28.287
18.000	61.217	117.920	68.410	17.745	28.823	28.842
19.000	64.618	125.502	72.966	18.143	29.859	29.410
20.000	68.018	133.036	77.506	18.519	30.853	29.986
21.000	71.419	141.413	83.143	19.351	31.819	30.570
22.000	74.820	148.543	87.389	19.678	32.762	31.160
23.000	78.221	155.660	91.624	19.990	33.686	31.753
24.000	82.515	162.784	95.889	20.321	34.576	32.310
25.000	86.046	169.876	100.117	20.611	35.468	32.907
26.000	89.569	176.957	104.340	20.889	36.347	33.505
27.000	93.085	184.028	108.559	21.156	37.215	34.105
28.000	96.594	191.089	112.773	21.413	38.071	34.705
29.000	100.097	198.141	116.983	21.660	38.916	35.305
30.000	103.596	205.185	121.190	21.899	39.752	35.905
31.000	107.089	212.221	125.393	22.130	40.579	36.504
32.000	110.577	219.251	129.593	22.353	41.397	37.102
33.000	114.061	226.273	133.790	22.569	42.207	37.699
34.000	117.541	233.290	137.984	22.779	43.009	38.294
35.000	121.018	240.301	142.175	22.982	43.804	38.888
36.000	124.491	247.307	146.364	23.180	44.592	39.480
37.000	127.962	254.308	150.551	23.372	45.373	40.070
38.000	131.429	261.304	154.736	23.558	46.149	40.659
39.000	134.893	268.296	158.919	23.740	46.918	41.245

P= 8.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	138.312	275.166	163.017	23.798	47.614	41.830
42.000	145.233	289.139	171.379	24.139	49.130	42.992
44.000	152.144	303.097	179.734	24.464	50.625	44.146
46.000	159.047	317.043	188.083	24.774	52.101	45.291
48.000	165.943	330.978	196.426	25.071	53.558	46.427
50.000	172.833	344.901	204.764	25.355	54.998	47.555
52.000	179.717	358.816	213.098	25.628	56.422	48.673
54.000	186.596	372.723	221.428	25.890	57.829	49.783
56.000	193.470	386.622	229.754	26.143	59.221	50.884
58.000	200.340	400.514	238.077	26.387	60.598	51.976
60.000	207.206	414.400	246.397	26.622	61.961	53.060
62.000	214.069	428.280	254.71[illegible]	26.850	63.310	54.135
64.000	220.928	442.155	263.029	27.070	64.646	55.202
66.000	227.784	456.025	271.342	27.284	65.969	56.261
68.000	234.638	469.891	279.651	27.491	67.280	57.312
70.000	241.488	483.752	287.960	27.691	68.578	58.355
72.000	248.337	497.610	296.266	27.887	69.864	59.390
74.000	255.183	511.464	304.571	28.076	71.139	60.417
76.000	262.027	525.315	312.874	28.261	72.403	61.437
78.000	268.870	539.162	321.175	28.441	73.656	62.449
80.000	275.710	553.007	329.475	28.616	74.898	63.454
82.000	282.549	566.849	337.774	28.787	76.131	64.452
84.000	289.386	580.689	346.072	28.954	77.354	65.442
86.000	296.222	594.527	354.368	29.117	78.567	66.426
88.000	303.056	608.362	362.664	29.276	79.772	67.402
90.000	309.890	622.195	370.958	29.431	80.967	68.372
92.000	316.722	636.026	379.252	29.583	82.155	69.335
94.000	323.552	649.855	387.544	29.732	83.334	70.291
96.000	330.382	663.683	395.836	29.878	84.506	71.241
98.000	337.211	677.509	404.127	30.020	85.671	72.185
100.000	344.039	691.333	412.417	30.160	86.829	73.122

P = 9.00 ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	10.166	4.268	-5.092	2.929		
2.000	10.269	5.550	-3.814	3.851		
3.000	10.587	6.738	-2.916	4.773		
4.000	11.101	10.239	0.116	6.103		33.299
5.000	12.069	14.421	3.415	7.124		33.338
6.000	13.803	20.926	8.339	8.281		32.278
7.000	16.223	28.571	13.777	9.468		30.836
8.000	19.231	37.100	19.563	10.569		29.481
9.000	22.567	45.656	25.332	11.528		28.536
10.000	26.164	54.751	30.869	12.691		27.863
11.000	29.799	62.413	35.231	13.443		27.558
12.000	33.183	70.197	39.699	14.121		27.560
13.000	36.910	78.142	44.351	14.783	20.140	27.628
14.000	40.547	86.083	49.038	15.387	23.558	27.842
15.000	44.104	93.988	53.736	15.943	25.496	28.156
16.000	47.592	101.840	58.428	16.457	26.886	28.543
17.000	51.392	109.671	63.148	16.957	28.030	28.939
18.000	54.415	117.364	67.758	17.381	29.110	29.457
19.000	57.438	125.008	72.356	17.781	30.127	29.992
20.000	61.023	132.637	75.983	18.189	31.084	30.492
21.000	63.484	141.142	82.730	19.002	32.056	31.095
22.000	67.210	148.314	87.017	19.361	32.964	31.612
23.000	70.374	155.451	91.265	19.679	33.874	32.179
24.000	73.529	162.574	95.508	19.983	34.770	32.751
25.000	76.677	169.684	99.745	20.273	35.652	33.328
26.000	79.817	176.782	103.977	20.552	36.522	33.909
27.000	82.950	183.869	108.203	20.820	37.381	34.493
28.000	86.077	190.946	112.426	21.077	38.229	35.078
29.000	89.199	198.013	116.643	21.325	39.067	35.664
30.000	92.316	205.071	120.857	21.565	39.896	36.251
31.000	95.428	212.121	125.067	21.796	40.716	36.838
32.000	98.535	219.164	129.274	22.020	41.528	37.425
33.000	101.639	226.199	133.477	22.236	42.332	38.011
34.000	104.739	233.228	137.678	22.446	43.129	38.597
35.000	107.835	240.251	141.875	22.650	43.918	39.181
36.000	110.928	247.268	146.070	22.848	44.702	39.764
37.000	114.018	254.280	150.262	23.040	45.479	40.346
38.000	117.106	261.287	154.453	23.227	46.250	40.927
39.000	120.191	268.289	158.640	23.409	47.015	41.506

P= 9.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µ POISES	TH.COND J./CM /SEC/ DEG.X 100000
40.000	123.230	275.156	162.736	23.467	47.709	42.084
42.000	129.391	289.148	171.108	23.809	49.218	43.233
44.000	135.544	303.125	179.472	24.134	50.707	44.375
46.000	141.689	317.088	187.830	24.444	52.177	45.509
48.000	147.827	331.038	196.181	24.741	53.630	46.636
50.000	153.959	344.977	204.527	25.026	55.066	47.754
52.000	160.086	358.906	212.868	25.299	56.485	48.864
54.000	166.206	372.826	221.205	25.562	57.889	49.966
56.000	172.325	386.737	229.537	25.815	59.278	51.060
58.000	178.438	400.641	237.866	26.059	60.652	52.146
60.000	184.547	414.538	246.192	26.294	62.013	53.224
62.000	190.652	428.429	254.515	26.522	63.360	54.294
64.000	196.755	442.314	262.834	26.742	64.694	55.355
66.000	202.855	456.193	271.151	26.956	66.015	56.409
68.000	208.952	470.068	279.466	27.163	67.324	57.456
70.000	215.046	483.938	287.779	27.364	68.620	58.494
72.000	221.138	497.804	296.089	27.560	69.906	59.525
74.000	227.228	511.666	304.398	27.749	71.179	60.548
76.000	233.316	525.524	312.705	27.934	72.442	61.564
78.000	239.402	539.379	321.010	28.114	73.694	62.573
80.000	245.486	553.231	329.313	28.290	74.936	63.575
82.000	251.569	567.080	337.615	28.461	76.168	64.569
84.000	257.650	580.926	345.917	28.627	77.390	65.557
86.000	263.730	594.769	354.216	28.790	78.603	66.537
88.000	269.808	608.610	362.514	28.949	79.807	67.511
90.000	275.885	622.449	370.811	29.105	81.003	68.478
92.000	281.961	636.286	379.108	29.257	82.190	69.439
94.000	288.036	650.120	387.403	29.406	83.370	70.393
96.000	294.109	663.953	395.698	29.551	84.541	71.340
98.000	300.182	677.784	403.991	29.694	85.706	72.282
100.000	306.254	691.613	412.283	29.834	86.864	73.217

P= 10.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	10.040	4.621	-5.552	2.197		
2.000	10.133	6.562	-3.705	3.840		
3.000	10.411	7.683	-2.866	4.733		
4.000	10.889	11.133	0.100	6.027		33.717
5.000	11.737	15.142	3.250	7.018		33.913
6.000	13.120	21.[illegible]	7.[illegible]	[illegible].076		33.242
7.000	15.146	28.361	13.014	9.217		32.006
8.000	17.749	36.585	18.601	10.311		30.683
9.000	20.603	45.164	24.288	11.249		29.704
10.000	23.534	53.605	29.758	12.071		29.103
11.000	26.886	61.714	34.465	13.095		28.630
12.000	29.910	69.456	38.907	13.773		28.541
13.000	33.263	77.399	43.563	14.437	20.682	28.517
14.000	36.546	85.368	48.272	15.046	23.994	28.654
15.000	39.761	93.319	53.002	15.607	25.883	28.903
16.000	42.916	101.225	57.731	16.126	27.235	29.234
17.000	46.253	109.103	62.481	16.624	28.351	29.592
18.000	48.973	116.854	67.129	17.050	29.408	30.074
19.000	51.654	124.556	71.766	17.454	30.404	30.575
20.000	55.064	132.251	76.449	17.872	31.332	31.027
21.000	57.788	140.927	82.366	18.721	32.269	31.562
22.000	60.652	148.056	86.629	19.056	33.182	32.096
23.000	63.507	155.249	90.885	19.374	34.079	32.639
24.000	66.354	162.388	95.136	19.679	34.963	33.191
25.000	69.194	169.514	99.381	19.970	35.834	33.750
26.000	72.027	176.628	103.621	20.250	36.695	34.313
27.000	74.853	183.730	107.855	20.518	37.545	34.881
28.000	77.674	190.821	112.085	20.776	38.385	35.451
29.000	80.490	197.902	116.310	21.025	39.216	36.023
30.000	83.301	204.974	120.531	21.265	40.037	36.597
31.000	86.107	212.037	124.748	21.496	40.851	37.173
32.000	88.910	219.092	128.961	21.720	41.657	37.748
33.000	91.709	226.139	133.170	21.937	42.455	38.324
34.000	94.504	233.180	137.377	22.148	43.246	38.900
35.000	97.295	240.214	141.580	22.352	44.031	39.475
36.000	100.084	247.242	145.780	22.550	44.809	40.049
37.000	102.870	254.264	149.978	22.742	45.582	40.623
38.000	105.653	261.281	154.173	22.929	46.348	41.196
39.000	108.434	268.292	158.366	23.112	47.110	41.768

P= 10.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM./SEC/ DEG.X 100000
40.000	111.169	275.156	162.459	23.170	47.802	42.339
42.000	116.723	289.167	170.841	23.512	49.304	43.475
44.000	122.269	303.162	179.214	23.838	50.788	44.605
46.000	127.807	317.141	187.580	24.149	52.252	45.729
48.000	133.338	331.106	195.939	24.446	53.700	46.845
50.000	138.864	345.060	204.292	24.731	55.132	47.955
52.000	144.384	359.002	212.641	25.004	56.548	49.057
54.000	149.900	372.935	220.984	25.267	57.948	50.151
56.000	155.411	386.859	229.323	25.520	59.334	51.238
58.000	160.918	400.774	237.657	25.765	60.706	52.317
60.000	166.421	414.682	245.989	26.000	62.064	53.389
62.000	171.922	428.583	254.316	26.228	63.409	54.453
64.000	177.419	442.477	262.641	26.449	64.741	55.509
66.000	182.913	456.366	270.963	26.663	66.060	56.558
68.000	188.404	470.250	279.282	26.870	67.367	57.600
70.000	193.893	484.128	287.599	27.071	68.663	58.634
72.000	199.380	498.002	295.914	27.267	69.947	59.661
74.000	204.865	511.872	304.226	27.457	71.219	60.680
76.000	210.348	525.737	312.536	27.642	72.481	61.692
78.000	215.829	539.599	320.845	27.822	73.733	62.698
80.000	221.308	553.458	329.152	27.997	74.974	63.696
82.000	226.786	567.313	337.458	28.168	76.205	64.687
84.000	232.262	581.165	345.762	28.335	77.427	65.672
86.000	237.737	595.015	354.064	28.498	78.640	66.649
88.000	243.210	608.862	362.365	28.657	79.843	67.620
90.000	248.682	622.706	370.666	28.813	81.038	68.585
92.000	254.153	636.548	378.964	28.965	82.226	69.543
94.000	259.623	650.387	387.262	29.114	83.405	70.494
96.000	265.092	664.225	395.559	29.260	84.576	71.440
98.000	270.560	678.061	403.855	29.402	85.741	72.379
100.000	276.027	691.894	412.150	29.542	86.899	73.312

P= 11.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µ POISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	9.927	5.634	-5.431	2.197		
2.000	10.007	7.543	-3.611	3.821		
3.000	10.275	8.631	-2.822	4.699		
4.000	10.690	11.998	0.083	5.957		34.122
5.000	11.495	15.966	3.150	6.942		34.343
6.000	12.576	21.411	7.394	7.907		34.072
7.000	14.330	28.423	12.451	9.021		32.991
8.000	16.538	36.239	17.805	10.089		31.806
9.000	19.032	44.555	23.343	10.997		30.829
10.000	21.790	53.233	28.946	11.836		30.079
11.000	24.208	61.067	34.085	12.569		29.829
12.000	27.497	68.893	38.243	13.485		29.406
13.000	30.330	76.765	42.833	14.126	21.277	29.382
14.000	33.313	84.745	47.555	14.738	24.468	29.449
15.000	36.241	92.726	52.309	15.302	26.297	29.637
16.000	39.117	100.675	57.070	15.824	27.603	29.916
17.000	42.048	108.587	61.838	16.318	28.690	30.244
18.000	44.521	116.390	66.521	16.747	29.718	30.690
19.000	47.484	124.189	71.259	17.187	30.656	31.093
20.000	50.202	131.903	75.936	17.585	31.584	31.557
21.000	52.690	140.722	81.981	18.443	32.504	32.067
22.000	55.300	147.904	86.251	18.779	33.400	32.576
23.000	57.901	155.072	90.515	19.098	34.284	33.098
24.000	60.495	162.226	94.773	19.403	35.155	33.630
25.000	63.082	169.366	99.026	19.695	36.016	34.170
26.000	65.663	176.494	103.273	19.975	36.867	34.716
27.000	68.238	183.610	107.515	20.244	37.708	35.268
28.000	70.807	190.714	111.751	20.503	38.540	35.823
29.000	73.372	197.808	115.983	20.752	39.363	36.382
30.000	75.933	204.893	120.210	20.992	40.177	36.944
31.000	78.489	211.968	124.434	21.225	40.984	37.507
32.000	81.041	219.035	128.653	21.449	41.784	38.072
33.000	83.590	226.093	132.868	21.666	42.576	38.637
34.000	86.135	233.145	137.080	21.877	43.362	39.203
35.000	88.678	240.190	141.289	22.081	44.141	39.769
36.000	91.217	247.228	145.494	22.280	44.915	40.335
37.000	93.754	254.260	149.697	22.473	45.683	40.901
38.000	96.288	261.286	153.897	22.660	46.445	41.466
39.000	98.820	268.307	158.095	22.842	47.203	42.030

P= 11.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY M.POISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	101.306	275.167	162.185	22.901	47.894	42.594
42.000	106.362	289.196	170.576	23.244	49.389	43.718
44.000	111.410	303.208	178.959	23.570	50.867	44.836
46.000	116.451	317.202	187.333	23.881	52.326	45.949
48.000	121.486	331.183	195.700	24.178	53.770	47.056
50.000	126.516	345.150	204.060	24.464	55.197	48.156
52.000	131.540	359.106	212.415	24.737	56.609	49.250
54.000	136.559	373.051	220.765	25.001	58.006	50.337
56.000	141.574	386.986	229.110	25.254	59.389	51.416
58.000	146.586	400.912	237.450	25.498	60.759	52.489
60.000	151.593	414.831	245.787	25.734	62.115	53.555
62.000	156.598	428.742	254.120	25.963	63.457	54.613
64.000	161.599	442.646	262.449	26.183	64.788	55.664
66.000	166.598	456.543	270.775	26.397	66.105	56.708
68.000	171.594	470.436	279.099	26.605	67.411	57.745
70.000	176.588	484.322	287.420	26.806	68.705	58.774
72.000	181.580	498.204	295.739	27.001	69.988	59.797
74.000	186.569	512.081	304.055	27.192	71.260	60.813
76.000	191.557	525.954	312.369	27.377	72.521	61.821
78.000	196.543	539.823	320.681	27.557	73.771	62.823
80.000	201.527	553.688	328.992	27.732	75.012	63.818
82.000	206.509	567.550	337.301	27.904	76.243	64.806
84.000	211.490	581.408	345.608	28.071	77.464	65.787
86.000	216.470	595.263	353.913	28.234	78.676	66.762
88.000	221.448	609.116	362.218	28.393	79.880	67.730
90.000	226.426	622.965	370.520	28.548	81.074	68.692
92.000	231.402	636.813	378.822	28.701	82.261	69.648
94.000	236.377	650.657	387.122	28.850	83.440	70.597
96.000	241.351	664.500	395.421	28.995	84.612	71.540
98.000	246.324	678.340	403.719	29.138	85.776	72.477
100.000	251.296	692.178	412.016	29.278	86.934	73.408

P= 12.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X 100000
1.000	9.821	6.852	-5.089	2.198		
2.000	9.857	8.521	-3.513	3.804		
3.000	10.136	9.560	-2.764	4.663		
4.000	10.514	12.884	0.100	5.891		34.490
5.000	11.286	16.774	3.051	6.862		34.738
6.000	12.139	21.756	6.996	7.761		34.785
7.000	13.680	28.571	11.937	8.842		33.849
8.000	15.547	36.013	17.109	9.866		32.840
9.000	17.798	44.204	22.563	10.781		31.836
10.000	20.225	52.676	28.084	11.600		31.086
11.000	22.669	60.952	33.389	12.366		30.638
12.000	24.721	68.521	38.462	12.953		30.600
13.000	27.930	76.234	42.160	13.843	21.917	30.220
14.000	30.653	84.208	46.885	14.456	24.980	30.224
15.000	33.335	92.207	51.656	15.023	26.739	30.357
16.000	35.975	100.188	56.442	15.549	27.993	30.587
17.000	38.544	108.122	61.219	16.035	29.049	30.895
18.000	41.135	116.010	65.990	16.493	30.012	31.247
19.000	43.663	123.832	70.731	16.920	30.938	31.649
20.000	46.162	131.591	75.443	17.321	31.842	32.084
21.000	48.455	140.545	81.608	18.189	32.742	32.568
22.000	50.851	147.739	85.884	18.525	33.621	33.054
23.000	53.239	154.920	90.154	18.845	34.490	33.554
24.000	55.621	162.086	94.419	19.151	35.348	34.066
25.000	57.997	169.240	98.679	19.444	36.198	34.588
26.000	60.368	176.380	102.933	19.724	37.038	35.118
27.000	62.732	183.508	107.181	19.994	37.870	35.654
28.000	65.092	190.625	111.424	20.253	38.693	36.195
29.000	67.448	197.731	115.662	20.503	39.508	36.741
30.000	69.759	204.827	119.896	20.743	40.316	37.290
31.000	72.146	211.914	124.125	20.976	41.116	37.841
32.000	74.490	218.992	128.350	21.201	41.909	38.395
33.000	76.830	226.061	132.571	21.419	42.695	38.950
34.000	79.167	233.123	136.788	21.630	43.476	39.506
35.000	81.501	240.178	141.002	21.834	44.250	40.063
36.000	83.832	247.225	145.213	22.033	45.019	40.620
37.000	86.161	254.267	149.421	22.226	45.782	41.178
38.000	88.487	261.302	153.626	22.414	46.541	41.735
39.000	90.811	268.332	157.828	22.596	47.294	42.292

P= 12.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μ POISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	93.090	275.188	161.916	22.655	47.984	42.850
42.000	97.721	289.234	170.316	22.998	49.473	43.961
44.000	102.365	303.262	178.706	23.324	50.945	45.067
46.000	106.991	317.272	187.088	23.636	52.399	46.170
48.000	111.612	331.267	195.463	23.934	53.838	47.267
50.000	116.228	345.247	203.830	24.219	55.262	48.358
52.000	120.838	359.216	212.192	24.493	56.670	49.444
54.000	125.444	373.173	220.548	24.757	58.064	50.523
56.000	130.046	387.119	228.899	25.010	59.445	51.595
58.000	134.644	401.056	237.245	25.255	60.811	52.662
60.000	139.238	414.985	245.587	25.491	62.165	53.721
62.000	143.829	428.906	253.924	25.720	63.506	54.774
64.000	148.418	442.819	262.259	25.940	64.834	55.819
66.000	153.004	456.726	270.590	26.154	66.151	56.858
68.000	157.587	470.626	278.917	26.362	67.455	57.890
70.000	162.168	484.521	287.243	26.563	68.748	58.916
72.000	166.747	498.410	295.565	26.759	70.030	59.934
74.000	171.323	512.295	303.885	26.949	71.300	60.946
76.000	175.898	526.175	312.203	27.135	72.560	61.950
78.000	180.471	540.050	320.519	27.315	73.810	62.949
80.000	185.043	553.922	328.833	27.490	75.050	63.940
82.000	189.613	567.789	337.144	27.662	76.280	64.925
84.000	194.181	581.654	345.455	27.829	77.501	65.903
86.000	198.748	595.515	353.763	27.992	78.713	66.875
88.000	203.314	609.373	362.070	28.151	79.916	67.841
90.000	207.879	623.228	370.375	28.307	81.110	68.800
92.000	212.443	637.080	378.680	28.459	82.297	69.753
94.000	217.005	650.930	386.982	28.608	83.476	70.700
96.000	221.567	664.777	395.284	28.754	84.647	71.641
98.000	226.127	678.622	403.584	28.897	85.812	72.576
100.000	230.687	692.464	411.884	29.037	86.970	73.504

P= 13.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X 100000
1.000	9.721	7.625	-5.180	2.198		
2.000	9.794	9.488	-3.413	3.790		
3.000	10.013	10.478	-2.711	4.630		
4.000	10.351	13.752	0.116	5.831		34.839
5.000	11.088	17.556	2.951	6.793		35.120
6.000	11.830	22.347	6.764	7.652		35.313
7.000	13.143	28.785	11.472	8.683		34.611
8.000	14.755	35.947	16.512	9.641		33.753
9.000	16.734	43.926	21.384	10.579		32.811
10.000	18.926	52.185	27.255	11.395		32.036
11.000	21.240	60.638	32.660	12.157		31.485
12.000	23.395	68.616	37.799	12.784		31.263
13.000	25.936	75.800	41.540	13.584	22.596	31.027
14.000	28.433	83.754	46.260	14.198	25.528	30.978
15.000	30.902	91.758	51.042	14.756	27.210	31.061
16.000	33.486	99.786	55.384	15.309	28.378	31.205
17.000	35.579	107.710	60.624	15.771	29.430	31.544
18.000	38.105	115.653	65.453	16.245	30.335	31.829
19.000	40.443	123.515	70.226	16.674	31.228	32.198
20.000	42.753	131.315	74.970	17.078	32.105	32.605
21.000	44.881	140.395	81.247	17.954	32.984	33.064
22.000	47.095	147.599	85.527	18.291	33.845	33.527
23.000	49.304	154.790	89.803	18.612	34.697	34.006
24.000	51.506	161.968	94.074	18.918	35.542	34.499
25.000	53.703	169.133	98.340	19.212	36.380	35.004
26.000	55.894	176.285	102.600	19.493	37.209	35.517
27.000	58.080	183.425	106.854	19.763	38.031	36.038
28.000	60.262	190.553	111.103	20.022	38.846	36.565
29.000	62.440	197.670	115.347	20.272	39.653	37.097
30.000	64.614	204.777	119.587	20.514	40.453	37.634
31.000	66.784	211.874	123.822	20.747	41.246	38.174
32.000	68.951	218.962	128.052	20.972	42.033	38.717
33.000	71.114	226.042	132.279	21.190	42.814	39.262
34.000	73.275	233.114	136.501	21.401	43.588	39.809
35.000	75.432	240.178	140.720	21.606	44.357	40.357
36.000	77.587	247.235	144.936	21.805	45.122	40.906
37.000	79.740	254.285	149.149	21.999	45.881	41.455
38.000	81.890	261.329	153.358	22.187	46.635	42.005
39.000	84.035	268.367	157.565	22.369	47.384	42.555

P= 13.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μ POISES	[illegible] J./CM./SEC./ DEG.K [illegible]
40.000	86.141	275.219	161.649	22.428	48.073	43.1[illegible]
42.000	90.431	289.281	170.058	22.772	49.556	[illegible]4.[illegible]
44.000	94.713	303.324	178.457	23.098	51.022	45.[illegible]
46.000	98.989	317.349	186.847	23.410	52.472	46.[illegible]
48.000	103.259	331.358	195.228	23.709	53.906	47.4[illegible]
50.000	107.524	345.351	203.603	23.994	55.326	48.[illegible]
52.000	111.784	359.332	211.971	24.269	56.731	49.[illegible]18
54.000	116.040	373.301	220.333	24.532	58.122	50.7[illegible]
56.000	120.292	387.258	228.689	24.786	59.499	51.7[illegible]5
58.000	124.540	401.206	237.041	25.031	60.864	52.83[illegible]
60.000	128.785	415.144	245.388	25.267	62.215	53.938
62.000	133.026	429.074	253.731	25.496	63.554	54.935
64.000	137.265	442.997	262.070	25.717	64.881	55.9[illegible]5
66.000	141.501	456.912	270.405	25.931	66.196	57.009
68.000	145.735	470.821	278.738	26.139	67.499	58.036
70.000	149.967	484.723	287.067	26.340	68.790	59.057
72.000	154.196	498.620	295.393	26.536	70.071	60.072
74.000	158.424	512.512	303.717	26.726	71.341	61.079
76.000	162.649	526.398	312.038	26.912	72.600	62.080
78.000	166.873	540.281	320.357	27.092	73.849	63.075
80.000	171.095	554.158	328.674	27.268	75.088	64.063
82.000	175.316	568.032	336.989	27.439	76.318	65.045
84.000	179.535	581.902	345.302	27.606	77.538	66.020
86.000	183.754	595.769	353.614	27.769	78.749	66.989
88.000	187.970	609.632	361.923	27.929	79.952	67.952
90.000	192.186	623.493	370.231	28.085	81.147	68.909
92.000	196.400	637.350	378.538	28.237	82.333	69.859
94.000	200.614	651.204	386.843	28.386	83.512	70.804
96.000	204.826	665.056	395.147	28.532	84.683	71.7[illegible]2
98.000	209.038	678.906	403.450	28.675	85.847	72.675
100.000	213.249	692.753	411.751	28.815	87.005	73.601

P= 14.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X 100000
1.000	9.629	8.609	-5.050	2.199		
2.000	9.695	10.450	-3.303	3.776		
3.000	9.857	11.400	-2.639	4.601		
4.000	10.209	14.615	0.133	5.781		35.152
5.000	10.905	18.371	2.901	6.726		35.490
6.000	11.565	22.966	6.532	7.579		35.750
7.000	12.672	29.034	11.058	8.533		35.324
8.000	14.118	35.976	15.949	9.445		34.550
9.000	15.852	43.781	21.237	10.400		33.664
10.000	17.828	51.833	26.542	11.199		32.936
11.000	19.937	60.146	31.864	11.945		32.354
12.000	22.115	68.607	37.235	12.605		31.974
13.000	23.946	76.077	42.109	13.189	23.446	31.959
14.000	26.555	83.378	45.679	13.959	26.105	31.709
15.000	28.836	91.378	50.466	14.529	27.707	31.747
16.000	31.054	99.394	55.289	15.059	28.835	31.889
17.000	33.319	107.389	60.119	15.553	29.787	32.114
18.000	35.519	115.341	64.941	16.014	30.670	32.403
19.000	37.692	123.238	69.743	16.446	31.528	32.741
20.000	39.841	131.074	74.517	16.852	32.376	33.120
21.000	41.927	140.273	80.397	17.737	33.231	33.554
22.000	43.885	147.484	85.181	18.074	34.072	33.996
23.000	45.938	154.684	89.462	18.395	34.908	34.455
24.000	47.985	161.872	93.738	18.702	35.738	34.929
25.000	50.028	169.046	98.009	18.996	36.563	35.416
26.000	52.065	176.209	102.274	19.278	37.381	35.914
27.000	54.099	183.359	106.534	19.548	38.193	36.420
28.000	56.128	190.497	110.789	19.808	38.998	36.933
29.000	58.153	197.625	115.039	20.059	39.797	37.453
30.000	60.174	204.742	119.284	20.301	40.589	37.977
31.000	62.192	211.849	123.524	20.534	41.376	38.506
32.000	64.207	218.946	127.759	20.760	42.156	39.038
33.000	66.219	226.035	131.991	20.978	42.931	39.574
34.000	68.228	233.116	136.219	21.190	43.700	40.111
35.000	70.234	240.189	140.443	21.395	44.464	40.650
36.000	72.238	247.255	144.663	21.594	45.223	41.190
37.000	74.239	254.314	148.880	21.788	45.978	41.732
38.000	76.239	261.366	153.094	21.976	46.728	42.274
39.000	78.236	268.413	157.305	22.159	47.473	42.817

P= 14.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X 100000
40.000	80.187	275.259	161.386	22.218	48.162	43.362
42.000	84.175	289.338	169.804	22.562	49.638	44.447
44.000	88.157	303.395	178.210	22.889	51.098	45.530
46.000	92.132	317.434	186.608	23.201	52.543	46.612
48.000	96.101	331.456	194.997	23.500	53.974	47.689
50.000	100.066	345.462	203.378	23.786	55.389	48.763
52.000	104.026	359.455	211.752	24.060	56.791	49.832
54.000	107.981	373.434	220.120	24.324	58.179	50.896
56.000	111.933	387.403	228.482	24.578	59.554	51.955
58.000	115.881	401.360	236.839	24.823	60.916	53.008
60.000	119.826	415.309	245.191	25.060	62.265	54.055
62.000	123.768	429.248	253.539	25.288	63.602	55.096
64.000	127.707	443.179	261.882	25.510	64.927	56.131
66.000	131.643	457.103	270.222	25.724	66.241	57.160
68.000	135.577	471.019	278.559	25.932	67.542	58.183
70.000	139.509	484.929	286.892	26.133	68.833	59.199
72.000	143.439	498.833	295.222	26.329	70.112	60.209
74.000	147.367	512.732	303.549	26.520	71.381	61.213
76.000	151.293	526.626	311.874	26.705	72.640	62.211
78.000	155.218	540.514	320.196	26.886	73.888	63.202
80.000	159.141	554.398	328.517	27.061	75.127	64.186
82.000	163.062	568.278	336.834	27.233	76.356	65.165
84.000	166.982	582.154	345.151	27.400	77.575	66.137
86.000	170.901	596.026	353.465	27.563	78.786	67.103
88.000	174.819	609.895	361.777	27.723	79.989	[illegible]8.063
90.000	178.735	623.760	370.088	27.879	81.183	69.017
92.000	182.650	637.622	378.397	28.031	82.369	69.966
94.000	186.565	651.481	386.705	28.180	83.548	70.908
96.000	190.478	665.338	395.011	28.326	84.719	71.844
98.000	194.390	679.192	403.316	28.469	85.883	72.774
100.000	198.302	693.043	411.620	28.609	87.041	73.699

P= 15.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μ POISES	TH.COND J./CM /SEC/ DEG.X 100000
1.000	9.536	9.583	-4.911	2.199		
2.000	9.599	11.413	-3.176	3.767		
3.000	9.784	12.319	-2.553	4.574		
4.000	10.070	15.487	0.183	5.728		35.465
5.000	10.733	19.164	2.852	6.663		35.829
6.000	11.369	23.680	6.400	7.492		36.146
7.000	12.278	29.371	[illegible]	8.388		35.957
8.000	13.581	36.142	[illegible]	9.280		35.273
9.000	15.156	43.725	[illegible]	10.211		34.477
10.000	16.890	51.533	[illegible]	11.027		33.787
11.000	18.856	59.827	31.168	[illegible]		33.158
12.000	20.922	68.338	36.539	[illegible]		32.708
13.000	22.779	76.166	41.546	[illegible]	24.045	32.575
14.000	24.426	83.545	46.420	13.548	26.926	32.665
15.000	27.064	91.061	49.925	14.308	28.226	32.416
16.000	29.021	99.060	54.719	14.823	29.325	32.570
17.000	31.237	107.094	59.609	15.335	30.182	32.711
18.000	33.289	115.072	64.454	15.798	31.019	32.967
19.000	35.318	122.999	69.281	16.233	31.838	33.276
20.000	37.325	130.867	74.093	16.641	32.654	33.629
21.000	39.187	140.176	80.558	17.533	33.484	34.039
22.000	41.109	147.393	[illegible]	17.871	34.304	34.460
23.000	43.027	154.600	89.130	18.193	35.121	34.899
24.000	44.940	161.795	93.410	18.501	35.936	35.356
25.000	46.848	168.979	97.686	18.795	36.747	35.826
26.000	48.752	176.150	101.956	19.077	37.553	36.308
27.000	50.652	183.309	106.221	19.348	38.355	36.799
28.000	52.549	190.457	110.481	19.609	39.151	37.299
29.000	54.441	197.594	114.736	19.860	39.941	37.806
30.000	56.330	204.720	118.986	20.102	40.726	38.319
31.000	58.216	211.837	123.231	20.336	41.505	38.837
32.000	60.099	218.943	127.472	20.561	42.279	39.358
33.000	61.979	226.041	131.708	20.780	43.047	39.884
34.000	63.857	233.131	135.941	20.992	43.811	40.412
35.000	65.732	240.212	140.169	21.198	44.570	40.942
36.000	67.604	247.286	144.394	21.397	45.324	41.474
37.000	69.475	254.353	148.615	21.591	46.074	42.008
38.000	71.343	261.413	152.833	21.779	46.820	42.543
39.000	73.209	268.467	157.049	21.963	47.562	43.078

P= 15.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	75.029	275.308	161.127	22.022	48.250	43.617
42.000	78.756	289.402	169.553	22.366	49.720	44.689
44.000	82.477	303.474	177.967	22.694	51.174	45.762
46.000	86.191	317.526	186.372	23.006	52.615	46.832
48.000	89.900	331.561	194.767	23.305	54.040	47.901
50.000	93.603	345.579	203.155	23.591	55.453	48.966
52.000	97.303	359.583	211.535	23.866	56.851	50.027
54.000	100.998	373.574	219.909	24.130	58.236	51.083
56.000	104.689	387.552	228.277	24.384	59.608	52.135
58.000	108.377	401.520	236.639	24.630	60.968	53.181
60.000	112.062	415.478	244.996	24.866	62.316	54.223
62.000	115.744	429.426	253.348	25.095	63.651	55.258
64.000	119.423	443.365	261.696	25.317	64.974	56.288
66.000	123.100	457.297	270.041	25.531	66.286	57.312
68.000	126.775	471.222	278.381	25.739	67.586	58.330
70.000	130.447	485.139	286.718	25.941	68.875	59.342
72.000	134.117	499.051	295.052	26.137	70.154	60.348
74.000	137.785	512.956	303.383	26.327	71.422	61.348
76.000	141.452	526.856	311.711	26.513	72.680	62.341
78.000	145.117	540.751	320.037	26.693	73.927	63.329
80.000	148.781	554.641	328.360	26.869	75.165	64.310
82.000	152.443	568.527	336.681	27.041	76.394	65.286
84.000	156.103	582.408	345.000	27.208	77.613	66.255
86.000	159.763	596.286	353.317	27.371	78.824	67.218
88.000	163.421	610.160	361.632	27.531	80.026	68.175
90.000	167.078	624.030	369.945	27.687	81.219	69.127
92.000	170.734	637.897	378.257	27.839	82.405	70.072
94.000	174.389	651.761	386.567	27.988	83.584	71.012
96.000	178.043	665.622	394.876	28.134	84.755	71.946
98.000	181.696	679.480	403.183	28.277	85.919	72.874
100.000	185.348	693.336	411.489	28.417	87.077	73.796

P= 16.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X 100000
1.000	9.453	10.548	-4.777	2.201		
2.000	9.513	12.352	-3.070	3.753		
3.000	9.682	13.227	-2.469	4.547		
4.000	9.947	16.358	0.232	5.689		35.746
5.000	10.567	19.950	2.819	6.600		36.173
6.000	11.174	24.415	6.300	7.419		36.517
7.000	11.950	29.734	10.362	8.272		36.510
8.000	13.123	36.362	15.087	9.134		35.927
9.000	14.539	43.747	20.176	10.022		35.213
10.000	16.117	51.395	25.266	10.864		34.554
11.000	17.891	59.576	30.571	11.587		33.949
12.000	19.851	68.091	35.909	12.257		33.435
13.000	21.664	76.105	40.982	12.887	24.696	33.221
14.000	23.345	83.803	45.956	13.415	27.426	33.213
15.000	24.864	91.040	50.730	13.916	29.028	33.371
16.000	27.485	98.824	54.260	14.634	29.759	33.138
17.000	29.425	106.848	59.124	15.131	30.594	33.295
18.000	31.346	114.844	63.990	15.597	31.381	33.522
19.000	33.247	122.796	68.840	16.033	32.159	33.804
20.000	35.129	130.693	73.667	16.443	32.941	34.131
21.000	36.884	140.105	80.230	17.343	33.743	34.518
22.000	38.687	147.326	84.519	17.681	34.540	34.918
23.000	40.485	154.538	88.807	18.004	35.338	35.339
24.000	42.280	161.739	93.091	18.312	36.137	35.778
25.000	44.071	168.930	97.370	18.607	36.934	36.232
26.000	45.858	176.109	101.645	18.889	37.728	36.698
27.000	47.641	183.277	105.915	19.161	38.518	37.176
28.000	49.421	190.433	110.180	19.422	39.304	37.663
29.000	51.197	197.578	114.439	19.673	40.086	38.157
30.000	52.970	204.713	118.694	19.915	40.862	38.658
31.000	54.740	211.838	122.944	20.149	41.634	39.165
32.000	56.508	218.953	127.189	20.376	42.401	39.677
33.000	58.272	226.059	131.430	20.595	43.164	40.193
34.000	60.035	233.156	135.667	20.807	43.921	40.712
35.000	61.795	240.246	139.900	21.013	44.675	41.233
36.000	63.552	247.328	144.129	21.213	45.425	41.757
37.000	65.308	254.402	148.355	21.407	46.170	42.283
38.000	67.061	261.470	152.577	21.595	46.912	42.811
39.000	68.813	268.531	156.796	21.779	47.650	43.339

P= 16.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM./SEC/ DEG.X100000
40.000	70.518	275.366	160.871	21.838	48.337	43.872
42.000	74.016	289.475	169.304	22.183	49.801	44.932
44.000	77.508	303.561	177.727	22.510	51.250	45.993
46.000	80.994	317.626	186.138	22.823	52.685	47.053
48.000	84.474	331.673	194.541	23.122	54.107	48.112
50.000	87.950	345.703	202.935	23.409	55.516	49.168
52.000	91.421	359.718	211.321	23.684	56.911	50.221
54.000	94.888	373.719	219.700	23.948	58.293	51.270
56.000	98.352	387.708	228.073	24.203	59.663	52.315
58.000	101.812	401.685	236.440	24.448	61.020	53.355
60.000	105.270	415.652	244.802	24.685	62.366	54.390
62.000	108.724	429.609	253.160	24.914	63.699	55.420
64.000	112.176	443.557	261.512	25.136	65.021	56.445
66.000	115.625	457.496	269.860	25.350	66.331	57.464
68.000	119.073	471.428	278.205	25.558	67.630	58.477
70.000	122.518	485.353	286.545	25.760	68.918	59.485
72.000	125.961	499.271	294.883	25.957	70.196	60.486
74.000	129.402	513.184	303.217	26.147	71.463	61.482
76.000	132.841	527.090	311.549	26.333	72.720	62.472
78.000	136.279	540.991	319.878	26.513	73.967	63.456
80.000	139.716	554.887	328.204	26.689	75.204	64.434
82.000	143.151	568.779	336.528	26.861	76.432	65.406
84.000	146.584	582.666	344.850	27.028	77.651	66.373
86.000	150.017	596.548	353.169	27.192	78.861	67.333
88.000	153.448	610.427	361.487	27.351	80.063	68.288
90.000	156.878	624.302	369.803	27.507	81.256	69.236
92.000	160.307	638.174	378.117	27.660	82.442	70.179
94.000	163.735	652.043	386.430	27.809	83.620	71.117
96.000	167.162	665.908	394.741	27.955	84.791	72.048
98.000	170.588	679.771	403.050	28.098	85.955	72.974
100.000	174.013	693.631	411.359	28.238	87.113	73.895

P= 17.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/DEG.X100000
1.000	9.373	11.501	-4.645	2.201		
2.000	9.430	13.286	-2.957	3.742		
3.000	9.586	14.122	-2.389	4.522		
4.000	9.824	17.188	0.266	5.646		36.033
5.000	10.418	20.730	2.796	6.547		36.490
6.000	10.955	25.172	6.234	7.353		36.866
7.000	11.688	30.245	10.113	8.159		36.969
8.000	12.752	36.688	14.722	9.008		36.487
9.000	14.015	43.870	19.729	9.863		35.881
10.000	15.444	51.372	24.768	10.699		35.276
11.000	17.059	59.359	29.974	11.428		34.695
12.000	18.889	67.800	35.263	12.098		34.152
13.000	20.623	75.943	40.418	12.724	25.384	33.883
14.000	22.308	83.884	45.458	13.273	27.969	33.786
15.000	23.859	91.398	50.299	13.767	29.465	33.861
16.000	26.016	98.617	53.789	14.442	30.245	33.740
17.000	27.836	106.646	58.655	14.940	31.020	33.868
18.000	29.640	114.657	63.548	15.407	31.756	34.067
19.000	31.427	122.630	68.420	15.845	32.490	34.323
20.000	33.198	130.551	73.270	16.256	33.237	34.626
21.000	34.857	140.059	79.913	17.164	34.009	34.991
22.000	36.554	147.281	84.203	17.503	34.782	35.371
23.000	38.247	154.496	88.493	17.826	35.560	35.774
24.000	39.937	161.703	92.780	18.134	36.341	36.196
25.000	41.624	168.900	97.063	18.429	37.1[illegible]	36.634
26.000	43.307	176.085	101.342	18.712	37.9[illegible]	37.086
27.000	44.987	183.260	105.616	18.984	38.68[illegible]	37.550
28.000	46.664	190.424	109.885	19.245	39.459	38.024
29.000	48.337	197.577	114.149	19.497	40.231	38.506
30.000	50.008	204.719	118.408	19.740	40.999	38.996
31.000	51.676	211.852	122.662	19.974	41.764	39.492
32.000	53.341	218.975	126.912	20.201	42.524	39.994
33.000	55.004	226.088	131.157	20.420	43.280	40.500
34.000	56.665	233.193	135.398	20.633	44.032	41.010
35.000	58.323	240.290	139.635	20.839	44.780	41.523
36.000	59.979	247.379	143.868	21.039	45.525	42.039
37.000	61.633	254.461	148.098	21.233	46.266	42.558
38.000	63.285	261.536	152.323	21.422	47.004	43.078
39.000	64.936	268.604	156.546	21.606	47.738	43.600

P= 17.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	66.540	275.433	160.618	21.665	48.425	44.126
42.000	69.835	289.555	169.059	22.010	49.882	45.174
44.000	73.125	303.654	177.489	22.338	51.326	46.223
46.000	76.409	317.732	185.907	22.651	52.756	47.274
48.000	79.688	331.791	194.316	22.951	54.174	48.323
50.000	82.962	345.833	202.716	23.238	55.579	49.371
52.000	86.232	359.858	211.108	23.513	56.971	50.416
54.000	89.498	373.870	219.493	23.778	58.350	51.457
56.000	92.761	387.868	227.872	24.032	59.717	52.495
58.000	96.021	401.855	236.244	24.278	61.073	53.529
60.000	99.277	415.830	244.610	24.515	62.416	54.558
62.000	102.531	429.796	252.972	24.744	63.748	55.582
64.000	105.782	443.752	261.328	24.966	65.068	56.602
66.000	109.031	457.699	269.681	25.181	66.377	57.616
68.000	112.277	471.638	278.029	25.389	67.674	58.624
70.000	115.521	485.571	286.374	25.591	68.961	59.628
72.000	118.764	499.496	294.715	25.787	70.238	60.625
74.000	122.005	513.414	303.053	25.978	71.504	61.617
76.000	125.244	527.327	311.388	26.163	72.760	62.603
78.000	128.481	541.234	319.720	26.344	74.006	63.584
80.000	131.717	555.136	328.049	26.520	75.243	64.559
82.000	134.952	569.033	336.376	26.692	76.471	65.527
84.000	138.185	582.925	344.701	26.859	77.689	66.491
86.000	141.417	596.813	353.023	27.023	78.899	67.448
88.000	144.648	610.697	361.343	27.182	80.100	68.400
90.000	147.878	624.577	369.662	27.339	81.293	69.346
92.000	151.107	638.454	377.979	27.491	82.479	70.287
94.000	154.334	652.327	386.293	27.640	83.657	71.221
96.000	157.561	666.197	394.606	27.786	84.827	72.151
98.000	160.787	680.063	402.918	27.929	85.991	73.074
100.000	164.012	693.927	411.228	28.070	87.149	73.993

P= 18.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µ POISES	TH.COND J./CM /SEC/ DEG.X 100000
1.000	9.257	12.442	-4.515	2.202		
2.000	9.350	14.215	-2.838	3.732		
3.000	9.456	15.028	-2.292	4.498		
4.000	9.718	18.040	0.315	5.609		36.285
5.000	10.269	21.514	2.786	6.488		36.815
6.000	10.829	25.901	6.151	7.290		37.197
7.000	11.472	30.854	9.931	8.073		37.360
8.000	12.434	37.117	14.440	8.905		36.990
9.000	13.551	44.013	19.298	9.714		36.511
10.000	14.874	51.359	24.271	10.546		35.932
11.000	16.340	59.261	29.460	11.276		35.394
12.000	18.007	67.475	34.633	11.952		34.869
13.000	19.715	75.812	39.855	12.585	26.053	34.512
14.000	21.320	83.845	44.961	13.127	28.548	34.378
15.000	22.891	91.618	49.868	13.644	29.936	34.372
16.000	24.267	99.135	54.375	14.085	30.935	34.546
17.000	26.430	106.487	58.231	14.759	31.460	34.429
18.000	28.129	114.509	63.128	15.227	32.142	34.602
19.000	29.815	122.499	68.019	15.667	32.832	34.834
20.000	31.486	130.441	72.890	16.080	33.541	35.114
21.000	33.060	140.036	79.606	16.995	34.282	35.457
22.000	34.662	147.258	83.896	17.334	35.030	35.819
23.000	36.262	154.475	88.188	17.657	35.786	36.204
24.000	37.859	161.686	92.477	17.966	36.549	36.609
25.000	39.452	168.887	96.763	18.262	37.315	37.032
26.000	41.043	176.078	101.045	18.545	38.082	37.470
27.000	42.631	183.259	105.323	18.817	38.849	37.920
28.000	44.216	190.429	109.595	19.079	39.615	38.382
29.000	45.798	197.589	113.863	19.331	40.377	38.852
30.000	47.377	204.738	118.127	19.574	41.137	39.331
31.000	48.954	211.878	122.385	19.809	41.894	39.817
32.000	50.529	219.008	126.639	20.036	42.647	40.309
33.000	52.101	226.129	130.888	20.255	43.397	40.805
34.000	53.671	233.241	135.133	20.468	44.143	41.307
35.000	55.238	240.345	139.374	20.675	44.886	41.812
36.000	56.804	247.441	143.611	20.875	45.625	42.320
37.000	58.368	254.529	147.844	21.069	46.362	42.831
38.000	59.930	261.611	152.074	21.258	47.095	43.344
39.000	61.490	268.685	156.300	21.443	47.825	43.859

P= 18.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	63.004	275.508	160.368	21.502	48.512	44.379
42.000	66.120	289.644	168.817	21.847	49.963	45.415
44.000	69.230	303.756	177.254	22.176	51.401	46.453
46.000	72.335	317.845	185.679	22.489	52.827	47.494
48.000	75.434	331.916	194.094	22.789	54.241	48.534
50.000	78.530	345.968	202.500	23.076	55.642	49.573
52.000	81.621	360.004	210.898	23.351	57.031	50.610
54.000	84.708	374.026	219.289	23.616	58.407	51.644
56.000	87.792	388.034	227.672	23.871	59.772	52.675
58.000	90.873	402.029	236.049	24.117	61.125	53.703
60.000	93.951	416.013	244.420	24.354	62.466	54.726
62.000	97.026	429.987	252.786	24.583	63.796	55.745
64.000	100.098	443.951	261.147	24.805	65.115	56.759
66.000	103.169	457.906	269.503	25.020	66.422	57.768
68.000	106.237	471.853	277.855	25.229	67.719	58.772
70.000	109.303	485.792	286.204	25.431	69.005	59.771
72.000	112.367	499.723	294.548	25.627	70.280	60.764
74.000	115.430	513.648	302.889	25.818	71.546	61.752
76.000	118.491	527.567	311.228	26.004	72.801	62.735
78.000	121.550	541.480	319.563	26.184	74.046	63.712
80.000	124.608	555.388	327.895	26.361	75.283	64.683
82.000	127.664	569.290	336.225	26.532	76.509	65.649
84.000	130.720	583.188	344.552	26.700	77.727	66.609
86.000	133.774	597.081	352.877	26.863	78.936	67.564
88.000	136.826	610.970	361.200	27.023	80.138	68.513
90.000	139.878	624.855	369.521	27.179	81.330	69.456
92.000	142.929	638.736	377.840	27.332	82.516	70.394
94.000	145.979	652.613	386.157	27.481	83.693	71.327
96.000	149.028	666.487	394.473	27.627	84.864	72.253
98.000	152.075	680.358	402.786	27.770	86.028	73.175
100.000	155.123	694.226	411.099	27.911	87.185	74.091

P= 19.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	9.224	13.380	-4.378	2.202		
2.000	9.271	15.148	-2.699	3.722		
3.000	9.410	15.919	-2.196	4.477		
4.000	9.612	18.870	0.365	5.569		36.542
5.000	10.123	22.273	2.786	6.428		37.140
6.000	10.673	26.649	6.101	7.227		37.516
7.000	11.277	31.491	9.782	7.986		37.725
8.000	12.155	37.559	14.158	8.809		37.447
9.000	13.156	44.278	18.949	9.589		37.075
10.000	14.360	51.486	23.840	10.390		36.562
11.000	15.716	59.269	29.013	11.133		36.045
12.000	17.245	67.301	34.102	11.806		35.543
13.000	18.859	75.632	39.324	12.446	26.747	35.154
14.000	20.408	83.719	44.430	12.987	29.144	34.972
15.000	21.966	91.759	49.470	13.548	30.436	34.899
16.000	23.369	99.366	54.378	13.989	31.344	35.004
17.000	24.586	106.517	59.185	14.390	32.145	35.256
18.000	26.783	114.398	62.729	15.058	32.540	35.127
19.000	28.377	122.400	67.637	15.499	33.184	35.336
20.000	29.958	130.360	72.528	15.913	33.854	35.595
21.000	31.456	140.037	79.310	16.835	34.563	35.917
22.000	32.973	147.256	83.599	17.174	35.283	36.260
23.000	34.489	154.474	87.891	17.498	36.018	36.629
24.000	36.002	161.687	92.182	17.807	36.761	37.018
25.000	37.512	168.891	96.471	18.103	37.511	37.426
26.000	39.020	176.087	100.755	18.387	38.264	37.850
27.000	40.525	183.273	105.036	18.659	39.018	38.288
28.000	42.028	190.449	109.312	18.921	39.773	38.737
29.000	43.528	197.615	113.584	19.174	40.526	39.196
30.000	45.026	204.770	117.851	19.417	41.277	39.664
31.000	46.521	211.916	122.113	19.652	42.025	40.139
32.000	48.014	219.053	126.370	19.879	42.771	40.621
33.000	49.505	226.180	130.623	20.099	43.514	41.109
34.000	50.993	233.299	134.872	20.312	44.254	41.602
35.000	52.480	240.410	139.117	20.512	44.992	42.099
36.000	53.965	247.512	143.357	20.719	45.726	42.599
37.000	55.448	254.607	147.594	20.914	46.458	43.103
38.000	56.929	261.694	151.828	21.103	47.187	43.609
39.000	58.409	268.775	156.058	21.288	47.913	44.117

P= 19.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μ POISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	59.842	275.591	160.122	21.347	48.600	44.631
42.000	62.797	289.740	168.578	21.693	50.044	45.655
44.000	65.746	303.864	177.021	22.022	51.477	46.683
46.000	68.690	317.965	185.453	22.335	52.898	47.713
48.000	71.629	332.047	193.875	22.635	54.308	48.744
50.000	74.564	346.110	202.286	22.923	55.705	49.774
52.000	77.495	360.156	210.690	23.198	57.091	50.804
54.000	80.422	374.187	219.085	23.464	58.465	51.831
56.000	83.346	388.204	227.474	23.719	59.827	52.855
58.000	86.267	402.208	235.855	23.965	61.178	53.876
60.000	89.185	416.201	244.231	24.202	62.517	54.893
62.000	92.101	430.182	252.601	24.431	63.845	55.907
64.000	95.014	444.154	260.966	24.653	65.162	56.916
66.000	97.924	458.116	269.327	24.868	66.468	57.920
68.000	100.833	472.070	277.683	25.077	67.764	58.919
70.000	103.740	486.016	286.034	25.279	69.048	59.914
72.000	106.644	499.954	294.383	25.476	70.323	60.903
74.000	109.547	513.885	302.727	25.667	71.587	61.887
76.000	112.449	527.810	311.068	25.852	72.842	62.866
78.000	115.348	541.729	319.407	26.033	74.087	63.840
80.000	118.247	555.642	327.742	26.210	75.322	64.808
82.000	121.144	569.550	336.074	26.381	76.548	65.770
84.000	124.040	583.453	344.404	26.549	77.766	66.727
86.000	126.935	597.351	352.732	26.713	78.975	67.679
88.000	129.828	611.245	361.058	26.872	80.175	68.625
90.000	132.721	625.134	369.381	27.029	81.368	69.566
92.000	135.612	639.020	377.702	27.181	82.553	70.502
94.000	138.502	652.902	386.022	27.331	83.730	71.432
96.000	141.392	666.780	394.339	27.477	84.901	72.356
98.000	144.281	680.655	402.655	27.620	86.064	73.276
100.000	147.168	694.527	410.969	27.760	87.221	74.190

P= 20.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY *POISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	9.158	14.320	-4.23[illegible]	2.204		
2.000	9.198	16.068	-2.571	3.714		
3.000	9.334	16.825	-2.090	4.462		
4.000	9.519	19.689	0.398	5.533		36.771
5.000	9.977	23.003	2.786	6.368		37.472
6.000	10.521	27.355	6.035	7.171		37.835
7.000	11.107	32.175	9.566	7.913		38.049
8.000	11.893	37.995	13.893	8.709		37.894
9.000	12.805	44.551	18.601	9.472		37.602
10.000	13.916	51.609	23.409	10.251		37.139
11.000	15.176	59.335	28.581	10.997		36.647
12.000	16.562	67.184	33.621	11.673		36.192
13.000	18.084	75.473	38.827	12.307	27.437	35.784
14.000	19.592	83.604	43.900	12.858	29.731	35.545
15.000	21.078	91.654	48.940	13.392	30.968	35.446
16.000	22.493	99.463	53.880	13.886	31.785	35.482
17.000	23.743	106.837	58.721	14.281	32.506	35.674
18.000	25.576	114.323	62.350	14.897	32.946	35.642
19.000	27.087	122.334	67.273	15.339	33.545	35.830
20.000	28.586	130.308	72.181	15.755	34.176	36.069
21.000	30.015	140.060	79.023	16.682	34.850	36.370
22.000	31.456	147.276	83.312	17.022	35.544	36.696
23.000	32.895	154.493	87.603	17.346	36.254	37.048
24.000	34.333	161.706	91.895	17.656	36.978	37.423
25.000	35.768	168.913	96.185	17.952	37.710	37.817
26.000	37.201	176.112	100.473	18.236	38.449	38.227
27.000	38.632	183.302	104.756	18.509	39.190	38.652
28.000	40.061	190.482	109.035	18.771	39.933	39.089
29.000	41.487	197.653	113.310	19.024	40.676	39.537
30.000	42.911	204.815	117.580	19.268	41.418	39.994
31.000	44.332	211.967	121.846	19.503	42.158	40.460
32.000	45.752	219.109	126.107	19.731	42.896	40.932
33.000	47.170	226.243	130.363	19.951	43.633	41.411
34.000	48.585	233.367	134.616	20.164	44.367	41.895
35.000	49.999	240.484	138.864	20.371	45.098	42.384
36.000	51.411	247.592	143.108	20.572	45.828	42.877
37.000	52.821	254.693	147.348	20.767	46.555	43.373
38.000	54.230	261.787	151.585	20.956	47.280	43.872
39.000	55.637	268.873	155.818	21.141	48.002	44.374

P= 20.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	56.997	275.683	159.879	21.200	48.688	44.882
42.000	59.807	289.844	168.342	21.546	50.126	45.894
44.000	62.611	303.979	176.792	21.875	51.553	46.912
46.000	65.411	318.092	185.230	22.189	52.970	47.932
48.000	68.205	332.184	193.657	22.490	54.375	48.954
50.000	70.996	346.257	202.075	22.777	55.769	49.976
52.000	73.783	360.313	210.483	23.053	57.151	50.997
54.000	76.566	374.353	218.884	23.318	58.522	52.017
56.000	79.346	388.379	227.277	23.574	59.882	53.035
58.000	82.122	402.392	235.664	23.820	61.231	54.049
60.000	84.897	416.393	244.044	24.057	62.568	55.061
62.000	87.668	430.382	252.418	24.287	63.894	56.069
64.000	90.437	444.361	260.787	24.509	65.210	57.072
66.000	93.204	458.331	269.151	24.724	66.515	58.072
68.000	95.969	472.291	277.511	24.933	67.809	59.067
70.000	98.732	486.244	285.866	25.135	69.092	60.057
72.000	101.493	500.188	294.218	25.332	70.366	61.042
74.000	104.253	514.126	302.566	25.523	71.629	62.022
76.000	107.011	528.057	310.910	25.709	72.883	62.997
78.000	109.767	541.981	319.251	25.890	74.127	63.968
80.000	112.522	555.900	327.590	26.066	75.362	64.932
82.000	115.276	569.813	335.925	26.238	76.588	65.892
84.000	118.028	583.721	344.258	26.406	77.805	66.846
86.000	120.779	597.624	352.588	26.569	79.013	67.795
88.000	123.529	611.522	360.916	26.729	80.213	68.738
90.000	126.279	625.416	369.241	26.886	81.405	69.677
92.000	129.027	639.306	377.565	27.038	82.590	70.610
94.000	131.774	653.192	385.887	27.188	83.767	71.537
96.000	134.520	667.075	394.207	27.334	84.937	72.460
98.000	137.265	680.954	402.524	27.477	86.101	73.377
100.000	140.010	694.830	410.841	27.617	87.258	74.289

P= 22.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X 100000
1.000	9.025	16.163	-3.955	2.206		
2.000	9.058	17.885	-2.307	3.697		
3.000	9.188	18.575	-1.905	4.423		
4.000	9.347	21.333	0.498	5.463		37.205
5.000	9.715	24.475	2.819	6.259		38.089
6.000	10.249	28.814	5.969	7.055		38.423
7.000	10.789	33.501	9.450	7.781		38.681
8.000	11.449	39.000	13.479	8.543		38.689
9.000	12.218	45.274	18.038	9.273		38.539
10.000	13.186	52.107	22.713	10.012		38.157
11.000	14.271	59.597	27.786	10.732		37.743
12.000	15.444	67.220	32.792	11.428		37.363
13.000	16.714	75.091	37.832	12.048	28.813	37.022
14.000	18.120	83.298	42.905	12.613	30.936	36.698
15.000	19.529	91.512	47.978	13.183	32.032	36.506
16.000	20.849	99.361	52.886	13.627	32.738	36.482
17.000	22.149	107.165	57.793	14.065	33.290	36.546
18.000	23.399	114.792	62.634	14.446	33.827	36.697
19.000	24.460	121.899	67.375	14.844	34.446	36.987
20.000	26.341	130.287	71.569	15.475	34.805	36.945
21.000	27.658	140.164	78.508	16.414	35.413	37.208
22.000	28.969	147.369	82.791	16.753	36.053	37.505
23.000	30.279	154.579	87.080	17.077	36.718	37.830
24.000	31.589	161.790	91.372	17.387	37.403	38.178
25.000	32.897	168.998	95.663	17.684	38.101	38.546
26.000	34.204	176.201	99.953	17.968	38.810	38.933
27.000	35.509	183.396	104.240	18.241	39.526	39.335
28.000	36.812	190.584	108.523	18.504	40.246	39.751
29.000	38.113	197.763	112.803	18.757	40.969	40.179
30.000	39.411	204.933	117.078	19.001	41.693	40.617
31.000	40.708	212.094	121.349	19.237	42.417	41.065
32.000	42.003	219.247	125.615	19.465	43.141	41.521
33.000	43.295	226.390	129.877	19.685	43.864	41.984
34.000	44.586	233.526	134.135	19.899	44.585	42.452
35.000	45.716	240.661	138.369	20.095	45.315	42.950
36.000	47.002	247.780	142.620	20.296	46.034	43.428
37.000	48.286	254.892	146.867	20.492	46.751	43.910
38.000	49.565	261.996	151.109	20.682	47.467	44.396
39.000	50.850	269.094	155.349	20.866	48.181	44.884

P= 22.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	52.086	275.888	159.403	20.926	48.867	45.381
42.000	54.644	290.072	167.878	21.272	50.291	46.370
44.000	57.198	304.229	176.341	21.602	51.707	47.366
46.000	59.748	318.363	184.790	21.917	53.114	48.367
48.000	62.293	332.4[illegible]	193.229	22.218	54.511	49.371
50.000	64.834	346.567	201.657	22.506	55.897	50.377
52.000	67.371	360.642	210.076	22.783	57.273	51.383
54.000	69.905	374.700	218.487	23.048	58.639	52.389
56.000	72.436	388.743	226.889	23.304	59.993	53.393
58.000	74.964	402.772	235.285	23.550	61.338	54.395
60.000	77.490	416.789	243.673	23.788	62.671	55.395
62.000	80.013	430.793	252.056	24.018	63.994	56.392
64.000	82.534	444.786	260.433	24.241	65.306	57.386
66.000	85.052	458.770	268.804	24.456	66.608	58.375
68.000	87.569	472.744	277.171	24.665	67.900	59.361
70.000	90.084	486.709	285.533	24.868	69.181	60.343
72.000	92.597	500.666	293.892	25.064	70.453	61.320
74.000	95.108	514.615	302.246	25.256	71.714	62.293
76.000	97.618	528.558	310.596	25.442	72.966	63.261
78.000	100.127	542.493	318.943	25.623	74.209	64.224
80.000	102.634	556.422	327.287	25.799	75.442	65.182
82.000	105.140	570.346	335.628	25.971	76.667	66.135
84.000	107.644	584.263	343.966	26.139	77.883	67.083
86.000	110.148	598.176	352.301	26.303	79.090	68.026
88.000	112.650	612.084	360.634	26.463	80.290	68.965
90.000	115.152	625.987	368.964	26.619	81.481	69.898
92.000	117.652	639.885	377.292	26.772	82.665	70.826
94.000	120.151	653.780	385.619	26.922	83.842	71.749
96.000	122.650	667.671	393.943	27.068	85.012	72.666
98.000	125.148	681.557	402.264	27.211	86.175	73.579
100.000	127.645	695.441	410.585	27.352	87.331	74.487

P= 26.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X 100000
1.000	8.909	17.981	-3.684	2.209		
2.000	8.936	19.674	-2.056	3.679		
3.000	9.055	20.326	-1.694	4.390		
4.000	9.191	22.564	0.614	5.410		37.608
5.000	9.493	25.969	2.885	6.159		38.632
6.000	9.990	30.229	5.935	6.945		39.006
7.000	10.517	34.860	9.284	7.665		39.246
8.000	11.071	40.103	13.180	8.394		39.407
9.000	11.741	46.058	17.507	9.097		39.358
10.000	12.593	52.772	22.149	9.807		39.058
11.000	13.554	60.018	27.056	10.506		38.699
12.000	14.566	67.484	32.063	11.189		38.393
13.000	15.663	75.159	37.070	11.819	30.042	38.101
14.000	16.903	83.148	42.043	12.384	32.098	37.785
15.000	18.176	91.318	47.116	12.921	33.125	37.565
16.000	19.450	99.321	52.023	13.415	33.698	37.453
17.000	20.723	107.358	56.964	13.859	34.117	37.429
18.000	21.966	115.255	61.838	14.247	34.531	37.497
19.000	23.067	122.441	66.347	14.655	35.037	37.700
20.000	24.115	129.830	71.188	14.987	35.590	37.965
21.000	25.631	140.348	78.014	16.160	36.013	38.046
22.000	26.829	147.536	82.289	16.499	36.599	38.315
23.000	28.028	154.736	86.573	16.823	37.216	38.613
24.000	29.228	161.940	90.861	17.133	37.859	38.936
25.000	30.426	169.145	95.152	17.430	38.521	39.281
26.000	31.624	176.348	99.442	17.715	39.198	39.645
27.000	32.820	183.546	103.731	17.988	39.886	40.025
28.000	34.015	190.737	108.017	18.252	40.581	40.420
29.000	35.208	197.922	112.309	18.505	41.282	40.829
30.000	36.399	205.099	116.580	18.749	41.985	41.248
31.000	37.589	212.267	120.855	18.985	42.692	41.678
32.000	38.777	219.428	125.127	19.214	43.399	42.117
33.000	39.964	226.580	129.394	19.434	44.108	42.564
34.000	41.149	233.725	133.657	19.648	44.817	43.017
35.000	42.332	240.861	137.916	19.856	45.525	43.477
36.000	43.513	247.989	142.171	20.057	46.234	43.942
37.000	44.693	255.111	146.423	20.252	46.942	44.412
38.000	45.872	262.224	150.671	20.443	47.649	44.886
39.000	47.049	269.331	154.915	20.627	48.355	45.364

P= 24.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	48.174	276.112	158.960	20.686	49.040	45.852
42.000	50.525	290.315	167.446	21.033	50.452	46.820
44.000	52.871	304.492	175.919	21.363	51.857	47.798
46.000	55.212	318.645	184.378	21.678	53.255	48.782
48.000	57.366	332.789	192.810	21.969	54.649	49.786
50.000	59.699	346.899	201.248	22.258	56.028	50.776
52.000	62.029	360.991	209.677	22.535	57.397	51.767
54.000	64.355	375.066	218.097	22.801	58.757	52.759
56.000	66.679	389.125	226.508	23.057	60.107	53.750
58.000	68.999	403.169	234.912	23.304	61.446	54.740
60.000	71.318	417.200	243.309	23.542	62.776	55.729
62.000	73.634	431.219	251.700	23.772	64.095	56.715
64.000	75.947	445.227	260.084	23.995	65.404	57.698
66.000	78.259	459.223	268.463	24.211	66.703	58.678
68.000	80.569	473.210	276.836	24.420	67.992	59.655
70.000	82.877	487.187	285.205	24.623	69.271	60.628
72.000	85.183	501.156	293.569	24.820	70.541	61.598
74.000	87.488	515.117	301.930	25.011	71.800	62.563
76.000	89.791	529.070	310.286	25.197	73.051	63.523
78.000	92.093	543.016	318.639	25.379	74.292	64.480
80.000	94.393	556.955	326.988	25.555	75.524	65.431
82.000	96.693	570.888	335.334	25.728	76.747	66.378
84.000	98.991	584.816	343.677	25.896	77.962	67.321
86.000	101.288	598.738	352.017	26.060	79.169	68.258
88.000	103.584	612.654	360.355	26.220	80.367	69.191
90.000	105.879	626.566	368.689	26.376	81.558	70.119
92.000	108.173	640.473	377.022	26.529	82.741	71.042
94.000	110.466	654.375	385.353	26.679	83.917	71.960
96.000	112.758	668.274	393.681	26.825	85.087	72.873
98.000	115.049	682.168	402.007	26.969	86.249	73.782
100.000	117.340	696.059	410.331	27.109	87.405	74.685

P= 26.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	8.800	19.786	-3.396	2.213		
2.000	8.823	21.446	-1.798	3.665		
3.000	8.932	22.057	-1.475	4.359		
4.000	9.055	24.552	0.697	5.360		37.968
5.000	9.310	27.479	2.951	6.080		39.094
6.000	9.748	31.600	5.919	6.829		39.573
7.000	10.272	36.229	9.168	7.549		39.776
8.000	10.753	41.292	12.965	8.265		40.042
9.000	11.333	46.958	17.142	8.938		40.102
10.000	12.099	53.525	21.652	9.638		39.864
11.000	12.971	60.697	26.526	10.324		39.543
12.000	13.856	67.903	31.400	10.964		39.306
13.000	14.838	75.479	36.390	11.607	31.149	39.042
14.000	15.895	83.189	41.314	12.162	33.205	38.797
15.000	17.036	91.167	46.287	12.626	34.188	38.575
16.000	18.206	99.224	51.261	13.213	34.687	38.429
17.000	19.426	107.346	56.168	13.660	34.992	38.335
18.000	20.623	115.373	61.042	14.048	35.301	38.339
19.000	21.734	123.107	65.850	14.473	35.693	38.461
20.000	22.818	130.771	70.658	14.824	36.142	38.644
21.000	23.929	140.605	77.556	15.927	36.626	38.852
22.000	25.031	147.772	81.821	16.266	37.159	39.097
23.000	26.135	154.957	86.098	16.590	37.729	39.372
24.000	27.240	162.150	90.382	16.900	38.330	39.672
25.000	28.345	169.349	94.669	17.197	38.955	39.995
26.000	29.450	176.548	98.959	17.482	39.600	40.337
27.000	30.554	183.744	103.248	17.756	40.258	40.698
28.000	31.656	190.937	107.535	18.019	40.928	41.074
29.000	32.758	198.125	111.821	18.273	41.605	41.463
30.000	33.855	205.366	116.103	18.518	42.288	41.866
31.000	34.958	212.480	120.381	18.754	42.976	42.279
32.000	36.055	219.647	124.657	18.982	43.667	42.702
33.000	37.152	226.806	128.928	19.203	44.360	43.133
34.000	38.247	233.958	133.195	19.418	45.055	43.572
35.000	39.340	241.102	137.459	19.625	45.751	44.018
36.000	40.432	248.238	141.719	19.827	46.448	44.470
37.000	41.523	255.368	145.975	20.023	47.145	44.927
38.000	42.612	262.490	150.228	20.213	47.843	45.389
39.000	43.700	269.605	154.477	20.398	48.541	45.856

P= 26.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY POISES	TH.COND J./CM./SEC/ DEG.X100000
40.000	44.736	276.369	158.513	20.457	49.225	46.333
42.000	46.909	290.592	167.010	20.804	50.623	47.281
44.000	49.077	304.787	175.493	21.135	52.016	48.239
46.000	51.241	318.958	183.963	21.450	53.403	49.205
48.000	53.401	333.105	192.420	21.752	54.783	50.176
50.000	55.558	347.233	200.867	22.040	56.155	51.152
52.000	57.710	361.341	209.303	22.317	57.518	52.130
54.000	59.860	375.431	217.731	22.583	58.872	53.109
56.000	62.007	389.506	226.150	22.839	60.217	54.089
58.000	64.151	403.565	234.561	23.086	61.553	55.069
60.000	66.095	417.628	242.950	23.315	62.883	56.060
62.000	68.236	431.660	251.348	23.546	64.198	57.036
64.000	70.374	445.680	259.740	23.769	65.504	58.010
66.000	72.511	459.689	268.125	23.985	66.800	58.981
68.000	74.645	473.688	276.506	24.194	68.087	59.949
70.000	76.778	487.677	284.881	24.397	69.363	60.913
72.000	78.910	501.657	293.251	24.594	70.630	61.875
74.000	81.039	515.629	301.618	24.786	71.888	62.832
76.000	83.168	529.593	309.980	24.972	73.137	63.786
78.000	85.295	543.549	318.338	25.154	74.376	64.735
80.000	87.420	557.498	326.692	25.331	75.607	65.681
82.000	89.545	571.441	335.043	25.503	76.829	66.621
84.000	91.668	585.378	343.391	25.671	78.043	67.558
86.000	93.790	599.308	351.736	25.835	79.248	68.490
88.000	95.912	613.233	360.078	25.996	80.446	69.417
90.000	98.032	627.154	368.417	26.152	81.635	70.340
92.000	100.151	641.069	376.754	26.305	82.818	71.258
94.000	102.270	654.979	385.089	26.455	83.993	72.172
96.000	104.387	668.885	393.421	26.602	85.162	73.080
98.000	106.504	682.787	401.750	26.745	86.324	73.985
100.000	108.620	696.685	410.078	26.886	87.480	74.884

P= 28.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY MPOISES	TH.COND J./CM /SEC/ DEG.X100000
1.000	8.697	21.570	-3.104	2.344		
2.000	8.720	23.200	-1.540	3.651		
3.000	8.820	23.781	-1.241	4.332		
4.000	8.929	26.129	0.796	5.311		38.309
5.000	9.155	28.990	3.018	6.010		39.499
6.000	9.526	32.961	5.936	6.726		40.114
7.000	10.050	37.614	9.102	7.449		40.273
8.000	10.481	42.534	12.799	8.146		40.610
9.000	10.998	48.047	16.844	8.799		40.746
10.000	11.678	54.352	21.221	9.478		40.595
11.000	12.444	61.299	25.995	10.142		40.363
12.000	13.302	68.626	30.886	10.781		40.075
13.000	14.151	75.892	35.743	11.402	32.196	39.895
14.000	15.086	83.485	40.684	11.960	34.218	39.694
15.000	16.057	91.228	45.558	12.536	35.184	39.499
16.000	17.112	99.014	50.465	12.984	35.683	39.392
17.000	18.269	107.270	55.439	13.475	35.888	39.241
18.000	19.410	115.380	60.313	13.876	36.102	39.192
19.000	20.477	123.217	65.120	14.281	36.407	39.262
20.000	21.558	131.125	69.961	14.649	36.760	39.377
21.000	22.480	140.928	77.134	15.712	37.245	39.627
22.000	23.500	148.071	81.386	16.051	37.729	39.852
23.000	24.522	155.237	85.654	16.375	38.254	40.105
24.000	25.545	162.416	89.931	16.684	38.814	40.385
25.000	26.570	169.605	94.214	16.981	39.403	40.687
26.000	27.594	176.797	98.501	17.266	40.015	41.011
27.000	28.619	183.990	102.789	17.540	40.644	41.352
28.000	29.642	191.182	107.076	17.804	41.287	41.711
29.000	30.665	198.369	111.362	18.058	41.940	42.083
30.000	31.687	205.553	115.646	18.303	42.602	42.469
31.000	32.708	212.730	119.927	18.539	43.270	42.867
32.000	33.728	219.901	124.205	18.768	43.943	43.275
33.000	34.747	227.065	128.479	18.989	44.621	43.692
34.000	35.764	234.223	132.750	19.204	45.301	44.117
35.000	36.781	241.373	137.017	19.412	45.984	44.550
36.000	37.796	248.516	141.281	19.614	46.669	44.989
37.000	38.810	255.653	145.541	19.810	47.356	45.434
38.000	39.822	262.782	149.798	20.000	48.043	45.885
39.000	40.834	269.905	154.051	20.186	48.732	46.340

P= 28.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	41.792	276.652	158.079	20.244	49.414	46.808
42.000	43.813	290.891	166.585	20.592	50.798	47.736
44.000	45.829	305.103	175.077	20.923	52.178	48.675
46.000	47.841	319.291	183.556	21.239	53.555	49.624
48.000	49.850	333.455	192.023	21.541	54.926	50.579
50.000	51.854	347.597	200.478	21.830	56.290	51.540
52.000	53.856	361.721	208.923	22.107	57.646	52.504
54.000	55.854	375.826	217.359	22.373	58.994	53.470
56.000	57.850	389.915	225.785	22.630	60.334	54.438
58.000	59.843	403.988	234.204	22.877	61.665	55.406
60.000	61.834	418.047	242.615	23.115	62.986	56.374
62.000	63.823	432.092	251.019	23.345	64.298	57.340
64.000	65.809	446.125	259.416	23.568	65.601	58.305
66.000	67.793	460.146	267.808	23.784	66.894	59.268
68.000	69.776	474.157	276.193	23.993	68.178	60.228
70.000	71.757	488.158	284.574	24.196	69.453	61.185
72.000	73.532	502.170	292.937	24.385	70.722	62.151
74.000	75.512	516.152	301.309	24.577	71.977	63.101
76.000	77.490	530.126	309.676	24.764	73.224	64.048
78.000	79.467	544.092	318.040	24.945	74.462	64.990
80.000	81.443	558.051	326.400	25.122	75.691	65.929
82.000	83.418	572.003	334.755	25.295	76.912	66.864
84.000	85.391	585.948	343.108	25.463	78.124	67.795
86.000	87.364	599.887	351.457	25.627	79.328	68.721
88.000	89.335	613.821	359.803	25.788	80.525	69.643
90.000	91.306	627.749	368.147	25.944	81.714	70.561
92.000	93.275	641.672	376.488	26.098	82.896	71.474
94.000	95.244	655.590	384.827	26.248	84.070	72.383
96.000	97.212	669.503	393.163	26.394	85.238	73.288
98.000	99.179	683.412	401.496	26.538	86.400	74.187
100.000	101.146	697.317	409.828	26.678	87.555	75.083

P= 30.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM./SEC/ DEG.X100000
1.000	8.601	23.327	-2.817	2.219		
2.000	8.627	24.931	-1.294	3.639		
3.000	8.717	25.482	-1.015	4.306		
4.000	8.810	27.708	0.929	5.261		38.639
5.000	9.019	30.498	3.084	5.944		39.861
6.000	9.347	34.364	5.952	6.640		40.564
7.000	9.844	38.960	9.036	7.350		40.749
8.000	10.242	43.783	12.650	8.039		41.128
9.000	10.710	49.166	16.612	8.676		41.327
10.000	11.313	55.245	20.356	9.339		41.264
11.000	12.006	62.026	25.531	9.989		41.089
12.000	12.775	69.206	30.372	10.599		40.860
13.000	13.571	76.399	35.147	11.229	33.196	40.674
14.000	14.413	83.866	40.054	11.754	35.171	40.506
15.000	15.308	91.462	44.928	12.294	36.130	40.354
16.000	16.204	99.057	49.802	12.788	36.521	40.278
17.000	17.235	107.099	54.709	13.276	36.798	40.143
18.000	18.319	115.268	59.583	13.710	36.922	40.044
19.000	19.357	123.264	64.424	14.101	37.134	40.057
20.000	20.381	131.219	69.265	14.503	37.421	40.136
21.000	21.233	141.313	76.744	15.513	37.864	40.373
22.000	22.180	148.429	80.983	15.851	38.303	40.579
23.000	23.131	155.572	85.240	16.174	38.785	40.814
24.000	24.084	162.735	89.509	16.484	39.308	41.075
25.000	25.038	169.910	93.786	16.781	39.862	41.359
26.000	25.993	177.093	98.068	17.066	40.441	41.665
27.000	26.948	184.280	102.353	17.340	41.042	41.990
28.000	27.903	191.467	106.639	17.603	41.658	42.332
29.000	28.857	198.653	110.924	17.857	42.287	42.689
30.000	29.811	205.836	115.208	18.103	42.927	43.059
31.000	30.764	213.015	119.491	18.339	43.575	43.442
32.000	31.716	220.189	123.770	18.568	44.230	43.836
33.000	32.668	227.357	128.047	18.790	44.891	44.239
34.000	33.618	234.518	132.320	19.005	45.556	44.652
35.000	34.567	241.673	136.591	19.213	46.225	45.072
36.000	35.515	248.822	140.857	19.415	46.898	45.499
37.000	36.462	255.964	145.121	19.611	47.573	45.933
38.000	37.408	263.100	149.381	19.802	48.250	46.372
39.000	38.353	270.229	153.638	19.988	48.929	46.816

P= 30.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µ POISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	39.246	276.959	157.656	20.046	49.610	47.276
42.000	41.134	291.213	166.172	20.395	50.978	48.184
44.000	43.018	305.440	174.672	20.726	52.346	49.105
46.000	44.898	319.643	183.160	21.042	53.711	50.037
48.000	46.774	333.822	191.634	21.344	55.072	50.977
50.000	48.648	347.979	200.098	21.634	56.428	51.923
52.000	50.518	362.117	208.551	21.911	57.777	52.874
54.000	52.386	376.236	216.994	22.178	59.119	53.828
56.000	54.250	390.338	225.428	22.434	60.453	54.784
58.000	56.113	404.425	233.853	22.682	61.779	55.741
60.000	57.973	418.496	242.271	22.920	63.096	56.698
62.000	59.830	432.554	250.681	23.151	64.405	57.654
64.000	61.686	446.599	259.085	23.374	65.704	58.610
66.000	63.540	460.632	267.483	23.590	66.994	59.564
68.000	65.392	474.654	275.875	23.799	68.275	60.516
70.000	67.243	488.665	284.260	24.002	69.547	61.465
72.000	69.092	502.667	292.642	24.200	70.810	62.412
74.000	70.940	516.660	301.018	24.391	72.064	63.356
76.000	72.786	530.644	309.391	24.578	73.309	64.296
78.000	74.631	544.620	317.758	24.759	74.545	65.233
80.000	76.475	558.588	326.122	24.936	75.773	66.167
82.000	78.317	572.549	334.482	25.109	76.992	67.096
84.000	79.950	586.527	342.827	25.269	78.207	68.031
86.000	81.793	600.475	351.181	25.433	79.410	68.952
88.000	83.635	614.417	359.532	25.594	80.605	69.869
90.000	85.476	628.352	367.879	25.751	81.793	70.782
92.000	87.315	642.283	376.225	25.904	82.974	71.690
94.000	89.155	656.208	384.567	26.054	84.148	72.595
96.000	90.993	670.129	392.906	26.201	85.315	73.494
98.000	92.830	684.045	401.244	26.345	86.476	74.390
100.000	94.667	697.956	409.579	26.485	87.630	75.281

P= 35.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X 100000
1.000	8.382	27.629	-2.097	2.228		
2.000	8.408	29.182	-0.637	3.607		
3.000	8.485	29.663	-0.427	4.247		
4.000	8.561	31.522	1.161	5.161		39.350
5.000	8.753	34.276	3.233	5.811		40.593
6.000	9.005	37.955	6.019	6.458		41.461
7.000	9.340	42.110	8.986	7.104		41.985
8.000	9.781	47.155	12.468	7.814		42.185
9.000	10.212	52.497	16.281	8.444		42.391
10.000	10.670	58.131	20.293	9.067		42.535
11.000	11.154	64.225	24.669	9.654		42.635
12.000	11.784	71.101	29.311	10.234		42.494
13.000	12.404	77.925	33.937	10.835	35.647	42.426
14.000	13.160	85.464	38.794	11.359	37.316	42.206
15.000	13.833	92.658	43.602	11.890	38.276	42.175
16.000	14.572	100.121	48.443	12.357	38.653	42.111
17.000	15.305	107.461	53.184	12.828	38.862	42.111
18.000	16.101	115.091	57.992	13.216	38.965	42.093
19.000	17.032	123.303	62.899	13.674	38.982	42.001
20.000	17.905	131.203	67.707	14.082	39.140	42.027
21.000	18.761	142.514	75.897	15.071	39.385	42.116
22.000	19.565	149.551	80.098	15.407	39.732	42.285
23.000	20.372	156.628	84.323	15.729	40.128	42.482
24.000	21.183	163.737	88.565	16.038	40.567	42.705
25.000	21.996	170.869	92.821	16.334	41.042	42.952
26.000	22.810	178.018	97.087	16.619	41.548	43.220
27.000	23.626	185.179	101.360	16.892	42.079	43.509
28.000	24.442	192.348	105.637	17.156	42.631	43.814
29.000	25.259	199.520	109.916	17.410	43.201	44.137
30.000	26.075	206.695	114.197	17.656	43.785	44.473
31.000	26.892	213.870	118.477	17.893	44.383	44.823
32.000	27.708	221.043	122.757	18.122	44.991	45.185
33.000	28.524	228.213	127.036	18.344	45.608	45.558
34.000	29.339	235.379	131.312	18.559	46.234	45.941
35.000	30.154	242.541	135.587	18.768	46.867	46.333
36.000	30.968	249.699	139.858	18.970	47.506	46.733
37.000	31.781	256.851	144.127	19.167	48.151	47.140
38.000	32.593	263.997	148.393	19.359	48.801	47.554
39.000	33.405	271.138	152.657	19.545	49.454	47.974

P= 35.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μ POISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	34.164	277.821	156.651	19.603	50.126	48.413
42.000	35.786	292.106	165.184	19.952	51.453	49.276
44.000	37.405	306.365	173.702	20.285	52.786	50.155
46.000	39.021	320.600	182.207	20.601	54.121	51.048
48.000	40.634	334.812	190.700	20.904	55.457	51.952
50.000	42.244	349.002	199.181	21.194	56.790	52.864
52.000	43.851	363.172	207.651	21.473	58.120	53.782
54.000	45.456	377.322	216.111	21.740	59.445	54.706
56.000	47.058	391.455	224.561	21.997	60.764	55.634
58.000	48.659	405.571	233.003	22.245	62.077	56.564
60.000	50.257	419.672	241.436	22.484	63.382	57.496
62.000	51.853	433.758	249.861	22.715	64.680	58.429
64.000	53.448	447.831	258.279	22.939	65.970	59.363
66.000	55.040	461.891	266.691	23.155	67.252	60.296
68.000	56.632	475.939	275.096	23.365	68.525	61.227
70.000	58.221	489.976	283.496	23.568	69.790	62.158
72.000	59.810	504.002	291.890	23.766	71.047	63.087
74.000	61.396	518.018	300.279	23.958	72.295	64.013
76.000	62.982	532.025	308.663	24.145	73.535	64.937
78.000	64.567	546.024	317.042	24.327	74.766	65.859
80.000	66.150	560.014	325.417	24.504	75.990	66.777
82.000	67.732	573.996	333.788	24.677	77.205	67.692
84.000	69.314	587.971	342.155	24.845	78.413	68.604
86.000	70.894	601.939	350.519	25.009	79.613	69.512
88.000	72.474	615.900	358.879	25.170	80.805	70.417
90.000	74.052	629.855	367.236	25.327	81.991	71.318
92.000	75.630	643.805	375.589	25.480	83.169	72.216
94.000	77.207	657.748	383.940	25.630	84.341	73.109
96.000	78.783	671.687	392.289	25.777	85.506	73.999
98.000	80.359	685.620	400.634	25.920	86.665	74.885
100.000	81.934	699.548	408.977	26.061	87.818	75.766

P= 40.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
2.000	8.216	33.338	0.037	3.576		
2.000	8.216	33.338	0.037	3.576		
3.000	8.282	33.761	0.192	4.195		
4.000	8.355	35.258	1.393	5.079		39.961
5.000	8.511	37.929	3.432	5.682		41.291
6.000	8.723	41.474	6.118	6.299		42.241
7.000	8.989	45.451	9.019	6.919		42.910
8.000	9.373	50.375	12.395	7.605		43.187
9.000	9.755	55.584	16.049	8.215		43.444
10.000	10.153	61.043	19.895	8.825		43.549
11.000	10.574	66.994	24.139	9.402		43.803
12.000	11.068	73.520	28.582	9.943		43.783
13.000	11.572	79.925	33.025	10.510	37.901	43.852
14.000	12.195	87.192	37.765	11.025	39.446	43.713
15.000	12.808	94.519	42.607	11.525	40.196	43.548
16.000	13.442	101.827	47.349	11.993	40.458	43.603
17.000	14.058	109.035	52.057	12.460	40.579	43.629
18.000	14.685	116.317	56.798	12.858	40.655	43.682
19.000	15.375	123.919	61.606	13.286	40.695	43.702
20.000	16.061	131.443	66.347	13.684	40.816	43.769
21.000	16.963	143.975	75.223	14.690	40.817	43.669
22.000	17.653	150.930	79.380	15.032	41.099	43.819
23.000	18.322	157.958	83.555	15.346	41.453	44.016
24.000	19.027	165.001	87.766	15.653	41.826	44.210
25.000	19.733	172.077	91.995	15.949	42.239	44.428
26.000	20.442	179.180	96.238	16.233	42.633	44.667
27.000	21.153	186.303	100.492	16.506	43.155	44.925
28.000	21.865	193.441	104.754	16.769	43.650	45.202
29.000	22.577	200.589	109.022	17.023	44.165	45.496
30.000	23.291	207.746	113.293	17.269	44.698	45.804
31.000	24.004	214.907	117.567	17.506	45.246	46.127
32.000	24.718	222.070	121.842	17.735	45.807	46.462
33.000	25.431	229.235	126.118	17.958	46.381	46.809
34.000	26.145	236.398	130.393	18.173	46.967	47.166
35.000	26.858	243.560	134.667	18.382	47.562	47.533
36.000	27.571	250.719	138.940	18.585	48.166	47.909
37.000	28.283	257.875	143.211	18.782	48.779	48.293
38.000	28.995	265.027	147.479	18.973	49.398	48.685
39.000	29.706	272.174	151.746	19.160	50.024	49.083

P= 40.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM./SEC/ DEG.X100000
40.000	30.364	278.807	155.715	19.218	50.684	49.504
42.000	31.787	293.114	164.259	19.568	51.965	50.326
44.000	33.206	307.397	172.791	19.901	53.260	51.168
46.000	34.623	321.657	181.309	20.219	54.562	52.025
48.000	36.038	335.896	189.816	20.522	55.869	52.895
50.000	37.450	350.112	198.311	20.813	57.178	53.776
52.000	38.860	364.309	206.795	21.092	58.486	54.665
54.000	40.267	378.486	215.269	21.360	59.792	55.561
56.000	41.673	392.646	223.733	21.617	61.095	56.462
58.000	43.076	406.789	232.188	21.866	62.392	57.368
60.000	44.478	420.915	240.634	22.105	63.685	58.277
62.000	45.878	435.027	249.073	22.337	64.970	59.188
64.000	47.276	449.124	257.504	22.561	66.250	60.100
66.000	48.673	463.208	265.928	22.778	67.522	61.013
68.000	50.068	477.280	274.345	22.988	68.787	61.926
70.000	51.462	491.339	282.756	23.192	70.044	62.838
72.000	52.854	505.388	291.162	23.390	71.294	63.750
74.000	54.245	519.426	299.561	23.582	72.535	64.660
76.000	55.635	533.455	307.956	23.769	73.769	65.568
78.000	57.025	547.474	316.346	23.951	74.996	66.475
80.000	58.412	561.484	324.731	24.129	76.214	67.379
82.000	59.799	575.486	333.112	24.302	77.425	68.280
84.000	61.185	589.480	341.489	24.470	78.628	69.179
86.000	62.571	603.466	349.861	24.635	79.825	70.075
88.000	63.955	617.446	358.230	24.796	81.014	70.968
90.000	65.338	631.418	366.596	24.953	82.196	71.858
92.000	66.721	645.385	374.959	25.106	83.371	72.744
94.000	68.103	659.345	383.318	25.256	84.540	73.627
96.000	69.484	673.300	391.674	25.403	85.703	74.506
98.000	70.865	687.249	400.028	25.547	86.859	75.382
100.000	72.245	701.192	408.378	25.688	88.010	76.254

P= 45.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM./SEC/ DEG.X100000
2.000	8.044	37.399	0.722	3.550		
3.000	8.110	37.773	0.794	4.147		
4.000	8.185	36.454	-0.828	4.317		40.484
5.000	8.329	45.247	7.287	6.121		41.837
6.000	8.506	51.100	12.306	7.019		42.871
7.000	8.725	55.492	15.700	7.549		43.641
8.000	8.989	59.389	18.424	7.954		44.195
9.000	9.298	63.363	21.044	8.341		44.575
10.000	9.642	67.813	23.860	8.744		44.840
11.000	10.034	72.743	27.013	9.181		44.985
12.000	10.465	78.239	30.541	9.645		45.052
13.000	10.933	84.270	34.427	10.126	40.044	45.066
14.000	11.435	90.766	38.629	10.617	41.559	45.047
15.000	11.961	97.672	43.090	11.105	42.192	45.024
16.000	12.519	104.863	47.762	11.589	42.305	44.988
17.000	13.094	112.304	52.589	12.060	42.234	44.970
18.000	13.684	119.926	57.529	12.514	42.142	44.975
19.000	14.283	127.672	62.543	12.951	42.105	45.008
20.000	14.890	135.499	67.604	13.369	42.150	45.070
21.000	15.569	145.675	74.676	14.374	42.204	45.088
22.000	16.174	152.542	78.789	14.703	42.427	45.225
23.000	16.784	159.469	82.935	15.020	42.707	45.385
24.000	17.400	166.447	87.108	15.324	43.035	45.566
25.000	18.019	173.466	91.304	15.617	43.402	45.768
26.000	18.642	180.519	95.519	15.899	43.802	45.989
27.000	19.240	187.622	99.737	16.166	44.245	46.249
28.000	19.870	194.720	103.979	16.429	44.692	46.502
29.000	20.502	201.836	108.230	16.682	45.159	46.772
30.000	21.135	208.966	112.488	16.928	45.644	47.057
31.000	21.768	216.105	116.751	17.165	46.147	47.356
32.000	22.402	223.251	121.017	17.394	46.665	47.669
33.000	23.036	230.402	125.286	17.616	47.198	47.993
34.000	23.669	237.556	129.556	17.832	47.743	48.328
35.000	24.303	244.712	133.826	18.041	48.301	48.674
36.000	24.937	251.867	138.096	18.244	48.871	49.029
37.000	25.571	259.021	142.366	18.441	49.451	49.393
38.000	26.204	266.173	146.634	18.633	50.040	49.764
39.000	26.837	273.323	150.901	18.820	50.637	50.143

P= 45.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μ POISES	TH.COND J./CM./SEC./ DEG.X100000
40.000	27.417	279.902	154.842	18.877	51.281	50.549
42.000	28.683	294.222	163.394	19.228	52.514	51.335
44.000	29.948	308.522	171.933	19.562	53.767	52.147
46.000	31.210	322.802	180.462	19.880	55.033	52.967
48.000	32.470	337.061	188.979	20.184	56.309	53.807
50.000	33.727	351.300	197.485	20.476	57.591	54.659
52.000	34.983	365.519	205.980	20.755	58.875	55.521
54.000	36.237	379.719	214.465	21.023	60.160	56.391
56.000	37.489	393.902	222.941	21.282	61.444	57.268
58.000	38.740	408.067	231.407	21.531	62.725	58.151
60.000	39.988	422.217	239.865	21.771	64.003	59.038
62.000	41.235	436.351	248.314	22.003	65.276	59.928
64.000	42.481	450.471	256.756	22.227	66.543	60.820
66.000	43.725	464.576	265.191	22.444	67.805	61.714
68.000	44.967	478.669	273.619	22.655	69.060	62.610
70.000	46.209	492.750	282.041	22.859	70.309	63.505
72.000	47.449	506.820	290.456	23.057	71.550	64.400
74.000	48.688	520.878	298.866	23.250	72.785	65.295
76.000	49.926	534.926	307.270	23.437	74.012	66.188
78.000	51.163	548.964	315.669	23.620	75.232	67.081
80.000	52.399	562.993	324.063	23.797	76.445	67.971
82.000	53.633	577.013	332.453	23.971	77.651	68.860
84.000	54.868	591.025	340.838	24.139	78.850	69.746
86.000	56.101	605.029	349.220	24.304	80.042	70.630
88.000	57.333	619.025	357.597	24.465	81.227	71.511
90.000	58.565	633.014	365.971	24.622	82.405	72.390
92.000	59.796	646.997	374.341	24.776	83.577	73.265
94.000	61.026	660.973	382.708	24.926	84.743	74.138
96.000	62.256	674.943	391.072	25.073	85.903	75.007
98.000	63.485	688.906	399.432	25.217	87.057	75.874
100.000	64.713	702.865	407.790	25.358	88.205	76.737

P= 50.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM./SEC/ DEG.X1000000
2.000	7.855	41.387	1.392	3.525		
3.000	7.954	41.712	1.414	4.105		
5.000	8.154	43.984	7.666	6.045		42.377
6.000	8.315	54.631	12.572	6.926		43.443
7.000	8.505	58.963	15.965	7.434		44.277
8.000	8.735	62.758	18.494	7.819		44.899
9.000	9.003	66.626	21.026	8.184		45.354
10.000	9.309	70.870	23.770	8.571		45.672
11.000	9.645	75.707	26.859	8.987		45.901
12.000	10.015	81.090	30.331	9.431		46.048
13.000	10.422	86.963	34.175	9.898	42.107	46.123
14.000	10.856	93.329	38.340	10.373	43.529	46.166
15.000	11.314	100.094	42.776	10.851	44.064	46.187
16.000	11.795	107.181	47.427	11.323	44.093	46.201
17.000	12.287	114.543	52.240	11.783	43.942	46.230
18.000	12.802	122.064	57.177	12.232	43.749	46.255
19.000	13.327	129.729	62.195	12.664	43.622	46.301
20.000	13.859	137.490	67.266	13.079	43.589	46.371
21.000	14.468	147.564	74.241	14.087	43.555	46.377
22.000	15.004	154.340	78.311	14.414	43.721	46.509
23.000	15.546	161.185	82.416	14.727	43.951	46.660
24.000	16.093	168.089	86.552	15.029	44.233	46.831
25.000	16.644	175.042	90.713	15.320	44.558	47.019
26.000	17.200	182.038	94.897	15.600	44.916	47.226
27.000	17.758	189.068	99.099	15.871	45.302	47.450
28.000	18.319	196.126	103.317	16.132	45.711	47.689
29.000	18.882	203.207	107.546	16.384	46.141	47.945
30.000	19.447	210.307	111.785	16.628	46.589	48.214
31.000	20.013	217.422	116.032	16.865	47.054	48.497
32.000	20.554	224.570	120.274	17.089	47.549	48.810
33.000	21.124	231.701	124.532	17.311	48.043	49.115
34.000	21.694	238.839	128.793	17.526	48.552	49.432
35.000	22.265	245.983	133.057	17.736	49.075	49.759
36.000	22.836	253.128	137.322	17.939	49.610	50.096
37.000	23.406	260.276	141.587	18.136	50.158	50.442
38.000	23.976	267.424	145.853	18.328	50.716	50.796
39.000	24.547	274.571	150.118	18.515	51.285	51.157

P= 50.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	25.064	281.094	154.029	18.572	51.911	51.550
42.000	26.206	295.421	162.583	18.924	53.096	52.304
44.000	27.345	309.731	171.127	19.258	54.305	53.080
46.000	28.483	324.024	179.662	19.577	55.533	53.876
48.000	29.619	338.299	188.186	19.881	56.776	54.687
50.000	30.754	352.555	196.700	20.173	58.028	55.513
52.000	31.886	366.793	205.204	20.453	59.287	56.350
54.000	33.017	381.013	213.698	20.722	60.549	57.196
56.000	34.146	395.215	222.183	20.981	61.813	58.051
58.000	35.274	409.401	230.658	21.230	63.076	58.912
60.000	36.400	423.571	239.126	21.471	64.338	59.779
62.000	37.524	437.725	247.585	21.703	65.596	60.649
64.000	38.648	451.864	256.036	21.928	66.850	61.523
66.000	39.769	465.990	264.480	22.145	68.100	62.400
68.000	40.890	480.103	272.917	22.356	69.345	63.272
70.000	42.009	494.203	281.348	22.561	70.584	64.198
72.000	43.128	508.291	289.772	22.759	71.817	65.037
74.000	44.245	522.368	298.190	22.952	73.043	65.917
76.000	45.361	536.434	306.603	23.140	74.263	66.797
78.000	46.476	550.490	315.011	23.322	75.477	67.676
80.000	47.590	564.537	323.413	23.500	76.684	68.553
82.000	48.704	578.574	331.811	23.674	77.884	69.419
84.000	49.816	592.602	340.204	23.843	79.077	70.304
86.000	50.928	606.622	348.593	24.008	80.264	71.176
88.000	52.039	620.635	356.978	24.169	81.445	72.046
90.000	53.149	634.639	365.359	24.326	82.619	72.914
92.000	54.258	648.637	373.737	24.480	83.787	73.780
94.000	55.367	662.628	382.110	24.631	84.949	74.642
96.000	56.475	676.613	390.481	24.778	86.106	75.502
98.000	57.583	690.591	398.848	24.922	87.257	76.359
100.000	58.690	704.563	407.212	25.063	88.402	77.213

P= 60.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
2.000	7.636	49.182	2.760	3.481		
3.000	7.692	49.427	2.662	4.033		
5.000	7.868	56.234	8.477	5.917		43.299
6.000	7.996	61.757	13.207	6.766		44.444
7.000	8.150	65.870	16.314	7.242		45.358
8.000	8.335	69.451	18.770	7.594		46.074
9.000	8.547	73.128	21.152	7.926		46.637
10.000	8.790	77.146	23.765	8.283		47.065
11.000	9.045	81.836	26.746	8.666		47.422
12.000	9.347	86.919	30.132	9.086		47.663
13.000	9.661	92.618	33.903	9.524	45.986	47.862
14.000	9.997	98.786	38.015	9.975	47.261	48.014
15.000	10.351	105.364	42.412	10.430	47.664	48.136
16.000	10.727	112.252	47.039	10.885	47.531	48.231
17.000	11.116	119.418	51.843	11.332	47.199	48.320
18.000	11.517	126.793	56.779	11.768	46.852	48.409
19.000	11.928	134.324	61.809	12.191	46.577	48.504
20.000	12.347	141.967	66.902	12.598	46.410	48.609
21.000	12.849	151.762	73.645	13.606	46.202	48.611
22.000	13.270	158.391	77.627	13.922	46.276	48.765
23.000	13.710	165.062	81.652	14.230	46.403	48.913
24.000	14.155	171.809	85.712	14.527	46.594	49.075
25.000	14.605	178.622	89.803	14.814	46.834	49.252
26.000	15.059	185.490	93.921	15.091	47.113	49.444
27.000	15.516	192.407	98.063	15.358	47.424	49.649
28.000	15.976	199.365	102.226	15.616	47.761	49.868
29.000	16.440	206.358	106.407	15.866	48.120	50.100
30.000	16.905	213.381	110.602	16.109	48.499	50.346
31.000	17.372	220.429	114.811	16.343	48.896	50.603
32.000	17.841	227.497	119.030	16.571	49.311	50.872
33.000	18.311	234.582	123.258	16.792	49.743	51.153
34.000	18.782	241.681	127.492	17.006	50.190	51.444
35.000	19.254	248.791	131.733	17.214	50.652	51.745
36.000	19.727	255.910	135.978	17.417	51.129	52.055
37.000	20.200	263.035	140.227	17.613	51.620	52.374
38.000	20.674	270.166	144.479	17.805	52.124	52.702
39.000	21.148	277.301	148.732	17.992	52.640	53.037

P= 60.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	21.569	283.709	152.579	18.047	53.231	53.412
42.000	22.495	298.055	161.113	18.395	54.332	54.127
44.000	23.448	312.368	169.656	18.730	55.454	54.850
46.000	24.399	326.673	178.193	19.050	56.605	55.595
48.000	25.349	340.966	186.723	19.355	57.777	56.358
50.000	26.298	355.244	195.245	19.648	58.967	57.137
52.000	27.246	369.508	203.759	19.929	60.171	57.930
54.000	28.192	383.757	212.264	20.199	61.383	58.734
56.000	29.137	397.990	220.761	20.458	62.602	59.548
58.000	30.080	412.208	229.250	20.708	63.825	60.371
60.000	31.022	426.411	237.731	20.949	65.051	61.201
62.000	31.963	440.599	246.205	21.183	66.277	62.037
64.000	32.903	454.773	254.670	21.408	67.502	62.877
66.000	33.842	468.933	263.129	21.626	68.726	63.721
68.000	34.779	483.080	271.581	21.838	69.947	64.569
70.000	35.715	497.214	280.026	22.043	71.164	65.419
72.000	36.651	511.335	288.464	22.242	72.377	66.271
74.000	37.585	525.446	296.897	22.435	73.585	67.123
76.000	38.518	539.544	305.324	22.623	74.788	67.977
78.000	39.451	553.633	313.746	22.807	75.986	68.831
80.000	40.383	567.711	322.162	22.985	77.179	69.684
82.000	41.314	581.779	330.574	23.159	78.366	70.537
84.000	42.244	595.838	338.980	23.328	79.548	71.389
86.000	43.173	609.889	347.383	23.494	80.724	72.240
88.000	44.102	623.930	355.780	23.655	81.894	73.090
90.000	45.030	637.964	364.174	23.813	83.059	73.938
92.000	45.957	651.990	372.564	23.967	84.218	74.784
94.000	46.884	666.009	380.950	24.118	85.372	75.628
96.000	47.810	680.020	389.333	24.266	86.520	76.471
98.000	48.735	694.025	397.711	24.410	87.664	77.310
100.000	49.660	708.023	406.087	24.551	88.803	78.148

P= 70.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X 100000
6.000	7.742	68.810	13.931	6.634		45.287
7.000	7.873	72.673	16.868	7.085		46.250
8.000	8.026	76.111	19.177	7.410		47.038
9.000	8.203	79.616	21.429	7.718		47.676
10.000	8.402	83.498	23.931	8.049		48.192
11.000	8.622	87.911	26.321	8.414		48.611
12.000	8.858	92.938	30.135	8.808		48.962
13.000	9.110	98.532	33.852	9.224	49.638	49.260
14.000	9.387	104.438	37.926	9.659	50.755	49.484
15.000	9.675	110.911	42.299	10.098	51.040	49.695
16.000	9.977	117.675	46.914	10.538	50.794	49.861
17.000	10.286	124.755	51.718	10.970	50.359	50.032
18.000	10.615	131.975	56.664	11.397	49.865	50.172
19.000	10.950	139.383	61.713	11.811	49.466	50.315
20.000	11.292	146.920	66.331	12.211	49.187	50.462
21.000	11.711	156.401	73.326	13.213	48.831	50.486
22.000	12.069	162.834	77.235	13.525	48.790	50.546
23.000	12.431	169.355	81.183	13.826	48.830	50.813
24.000	12.800	175.956	85.168	14.116	48.937	50.987
25.000	13.174	182.631	89.188	14.397	49.096	51.170
26.000	13.546	189.395	93.235	14.667	49.310	51.372
27.000	13.921	196.185	97.314	14.931	49.542	51.571
28.000	14.320	203.030	101.418	15.186	49.804	51.780
29.000	14.711	209.921	105.544	15.434	50.092	52.001
30.000	15.105	216.853	109.690	15.674	50.403	52.233
31.000	15.502	223.820	113.853	15.907	50.736	52.476
32.000	15.900	230.817	118.031	16.133	51.088	52.729
33.000	16.299	237.839	122.222	16.352	51.460	52.992
34.000	16.700	244.883	126.423	16.565	51.850	53.265
35.000	17.103	251.945	130.634	16.772	52.257	53.547
36.000	17.506	259.022	134.853	16.974	52.681	53.837
37.000	17.910	266.112	139.078	17.170	53.120	54.137
38.000	18.315	273.212	143.308	17.362	53.575	54.444
39.000	18.720	280.321	147.544	17.548	54.047	54.759

P= 70.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM./SEC/ DEG.X100000
40.000	19.074	286.610	151.321	17.602	54.600	55.120
42.000	19.888	300.908	159.846	17.953	55.603	55.780
44.000	20.703	315.211	168.372	18.288	56.647	56.465
46.000	21.517	329.515	176.898	18.608	57.725	57.172
48.000	22.331	343.814	185.422	18.913	58.832	57.898
50.000	23.145	358.105	193.941	19.206	59.961	58.640
52.000	23.958	372.385	202.455	19.487	61.108	59.398
54.000	24.747	386.678	210.953	19.754	62.277	60.179
56.000	25.560	400.932	219.455	20.014	63.449	60.959
58.000	26.372	415.173	227.951	20.265	64.629	61.748
60.000	27.183	429.400	236.440	20.507	65.816	62.546
62.000	27.993	443.615	244.922	20.740	67.006	63.351
64.000	28.801	457.815	253.397	20.967	68.199	64.162
66.000	29.609	472.003	261.865	21.185	69.393	64.978
68.000	30.416	486.178	270.327	21.397	70.587	65.798
70.000	31.222	500.341	278.782	21.603	71.779	66.622
72.000	32.026	514.491	287.232	21.803	72.969	67.449
74.000	32.830	528.630	295.675	21.997	74.157	68.277
76.000	33.633	542.758	304.113	22.185	75.341	[illegible].107
78.000	34.435	556.875	312.545	22.369	76.522	[illegible]9.939
80.000	35.237	570.981	320.973	22.548	77.699	70.771
82.000	36.037	585.077	329.395	22.722	78.871	71.603
84.000	36.837	599.164	337.812	22.892	80.038	72.435
86.000	37.637	613.241	346.225	23.058	81.201	73.266
88.000	38.435	627.310	354.633	23.219	82.360	74.097
90.000	39.233	641.370	363.037	23.377	83.513	74.927
92.000	40.030	655.422	371.437	23.532	84.662	75.756
94.000	40.827	669.466	379.833	23.683	85.806	76.583
96.000	41.623	683.502	388.225	23.831	86.946	77.408
98.000	42.415	697.531	396.614	23.976	88.081	78.232
100.000	43.214	711.553	404.999	24.117	89.212	79.054

P= 80.00 ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X1(0000)
6.000	7.532	75.755	14.710	6.521		46.013
7.000	7.645	79.457	17.503	6.951		47.020
8.000	7.778	82.702	19.675	7.254		47.854
9.000	7.928	85.085	21.312	7.543		48.552
10.000	8.059	89.907	24.216	7.856		49.128
11.000	8.283	94.126	27.029	8.201		49.619
12.000	8.481	99.069	30.284	8.577		50.043
13.000	8.690	104.475	33.955	8.931	53.023	50.390
14.000	8.926	110.340	37.999	9.309	54.077	50.699
15.000	9.163	116.701	42.358	9.823	54.292	50.979
16.000	9.414	123.309	46.909	10.253	53.915	51.208
17.000	9.680	130.240	51.779	10.677	53.347	51.426
18.000	9.951	137.394	56.741	11.093	52.770	51.631
19.000	10.229	144.727	61.013	11.499	52.280	51.827
20.000	10.510	152.212	65.961	11.891	51.930	52.027
21.000	10.968	161.360	73.215	12.884	51.446	52.080
22.000	11.171	167.680	77.058	13.130	51.315	52.265
23.000	11.479	173.956	80.934	13.434	51.271	52.453
24.000	11.793	180.456	84.850	13.769	51.297	52.643
25.000	12.112	186.935	88.801	14.045	51.377	52.337
26.000	12.436	193.593	92.785	14.312	51.500	53.037
27.000	12.764	200.260	96.800	14.571	51.660	53.243
28.000	13.096	207.003	100.843	14.823	51.850	53.456
29.000	13.423	213.826	104.928	15.064	52.084	53.690
30.000	13.764	220.654	109.041	15.302	52.322	53.916
31.000	14.107	227.525	113.115	15.532	52.585	54.150
32.000	14.452	234.442	117.247	15.756	52.873	54.394
33.000	14.799	241.390	121.395	15.974	53.183	54.647
34.000	15.147	248.367	125.559	16.186	53.515	54.908
35.000	15.494	255.371	129.733	16.392	53.866	55.178
36.000	15.847	262.396	133.921	16.593	54.238	55.455
37.000	16.199	269.441	138.117	16.788	54.627	55.741
38.000	16.552	276.501	142.321	16.979	55.035	56.034
39.000	16.905	283.575	146.533	17.164	55.458	56.334

P= 80.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µ POISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	17.209	289.741	150.239	17.217	55.981	56.687
42.000	17.920	303.996	158.731	17.568	56.903	57.316
44.000	18.632	318.271	167.233	17.902	57.873	57.969
46.000	19.345	332.556	175.740	18.222	58.882	58.644
48.000	20.059	346.846	184.250	18.528	59.924	59.338
50.000	20.772	361.136	192.759	18.821	60.994	60.050
52.000	21.485	375.421	201.266	19.102	62.087	60.777
54.000	22.197	389.699	209.770	19.372	63.198	61.517
56.000	22.909	403.969	218.270	19.632	64.324	62.270
58.000	23.620	418.229	226.765	19.883	65.462	63.032
60.000	24.330	432.477	235.255	20.125	66.610	63.804
62.000	25.040	446.714	243.739	20.359	67.764	64.584
64.000	25.749	460.938	252.218	20.586	68.924	65.370
66.000	26.457	475.151	260.690	20.805	70.088	66.163
68.000	27.142	489.376	269.148	21.014	71.259	66.969
70.000	27.850	503.563	277.611	21.220	72.424	67.769
72.000	28.557	517.738	286.067	21.421	73.590	68.573
74.000	29.263	531.901	294.518	21.615	74.755	69.380
76.000	29.969	546.054	302.963	21.804	75.919	70.189
78.000	30.673	560.196	311.404	21.988	77.080	71.000
80.000	31.377	574.327	319.839	22.167	78.239	71.813
82.000	32.080	588.448	328.269	22.342	79.394	72.626
84.000	32.782	602.560	336.694	22.512	80.546	73.440
86.000	33.484	616.662	345.115	22.678	81.695	74.254
88.000	34.185	630.755	353.531	22.841	82.840	75.067
90.000	34.886	644.839	361.944	22.999	83.981	75.881
92.000	35.585	658.914	370.352	23.154	85.119	76.693
94.000	36.285	672.982	378.756	23.305	86.252	77.505
96.000	36.984	687.042	387.156	23.453	87.382	78.315
98.000	37.682	701.094	395.553	23.598	88.507	79.124
100.000	38.380	715.138	403.946	23.740	89.629	79.932

P= 10.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
8.000	7.570	89.285	20.243	7.141		48.569
9.000	7.702	92.502	22.273	7.392		49.307
10.000	7.848	96.170	24.594	7.637		49.941
11.000	8.008	100.383	27.337	8.018		50.485
12.000	8.183	105.102	30.534	8.394		50.948
13.000	8.367	110.459	34.171	8.772	56.313	51.364
14.000	8.563	116.258	[illegible]	9.179	57.256	51.726
15.000	8.769	122.480	42.539	9.595	57.354	52.051
16.000	8.983	129.063	47.152	10.012	56.917	52.347
17.000	9.203	135.964	51.975	10.426	56.282	52.627
18.000	9.436	143.007	56.354	10.836	55.598	52.873
19.000	9.673	150.259	62.052	11.236	55.028	53.114
20.000	9.916	157.649	67.230	11.623	54.593	53.348
21.000	10.223	166.493	73.262	12.606	54.014	53.442
22.000	10.482	172.635	77.042	12.904	53.815	53.658
23.000	10.744	178.897	80.858	13.190	53.716	53.879
24.000	11.016	185.204	84.710	13.470	53.665	54.087
25.000	11.293	191.601	88.596	13.741	53.670	54.297
26.000	11.574	198.079	92.517	14.004	53.719	54.510
27.000	11.860	204.632	96.471	14.259	53.805	54.726
28.000	12.149	211.252	100.455	14.507	53.923	54.946
29.000	12.442	217.933	104.467	14.747	54.069	55.172
30.000	12.738	224.671	108.505	14.981	54.242	55.403
31.000	13.037	231.458	112.567	15.209	54.441	55.640
32.000	13.339	238.291	116.550	15.430	54.665	55.883
33.000	13.635	245.195	120.749	15.643	54.927	56.145
34.000	13.942	252.096	124.870	15.854	55.196	56.399
35.000	14.251	259.031	129.007	16.059	55.489	56.661
36.000	14.561	265.995	133.158	16.258	55.805	56.930
37.000	14.872	272.985	137.321	16.453	56.143	57.206
38.000	15.184	279.997	141.495	16.642	56.501	57.489
39.000	15.497	287.028	145.678	16.827	56.879	57.778

P= 90.00ATM.

TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY µPOISES	TH.COND J./CM /SEC/ DEG.X100000
40.000	15.762	293.069	149.310	16.879	57.368	58.127
42.000	16.393	307.265	157.762	17.228	58.209	58.732
44.000	17.025	321.497	166.231	17.562	59.106	59.361
46.000	17.659	335.752	174.711	17.881	60.048	60.011
48.000	18.293	350.022	183.199	18.187	61.030	60.680
50.000	18.927	364.300	191.692	18.480	62.044	61.366
52.000	19.562	378.580	200.186	18.761	63.084	62.068
54.000	20.197	392.860	208.680	19.032	64.147	62.784
56.000	20.831	407.135	217.173	19.292	65.228	63.512
58.000	21.464	421.404	225.663	19.544	66.324	64.251
60.000	22.098	435.665	234.150	19.786	67.433	65.000
62.000	22.730	449.917	242.633	20.020	68.551	65.757
64.000	23.362	464.159	251.111	20.247	69.677	66.521
66.000	23.994	478.390	259.585	20.466	70.809	67.292
68.000	24.624	492.611	268.054	20.679	71.946	68.069
70.000	25.254	506.820	276.518	20.885	73.085	68.850
72.000	25.884	521.019	284.978	21.086	74.226	69.635
74.000	26.513	535.207	293.432	21.280	75.368	70.424
76.000	27.141	549.384	301.881	21.469	76.511	71.215
78.000	27.768	563.550	310.326	21.654	77.652	72.009
80.000	28.395	577.705	318.765	21.833	78.792	72.804
82.000	29.000	591.878	327.193	22.005	79.935	73.608
84.000	29.626	606.012	335.624	22.176	81.070	74.406
86.000	30.252	620.136	344.051	22.343	82.204	75.203
88.000	30.878	634.251	352.473	22.505	83.334	76.001
90.000	31.503	648.358	360.892	22.664	84.462	76.799
92.000	32.127	662.456	369.306	22.819	85.587	77.597
94.000	32.751	676.545	377.717	22.971	86.708	78.394
96.000	33.374	690.626	386.123	23.119	87.827	79.191
98.000	33.996	704.700	394.526	23.264	88.942	79.987
100.000	34.619	718.766	402.926	23.407	90.054	80.781

P=100.00ATM.

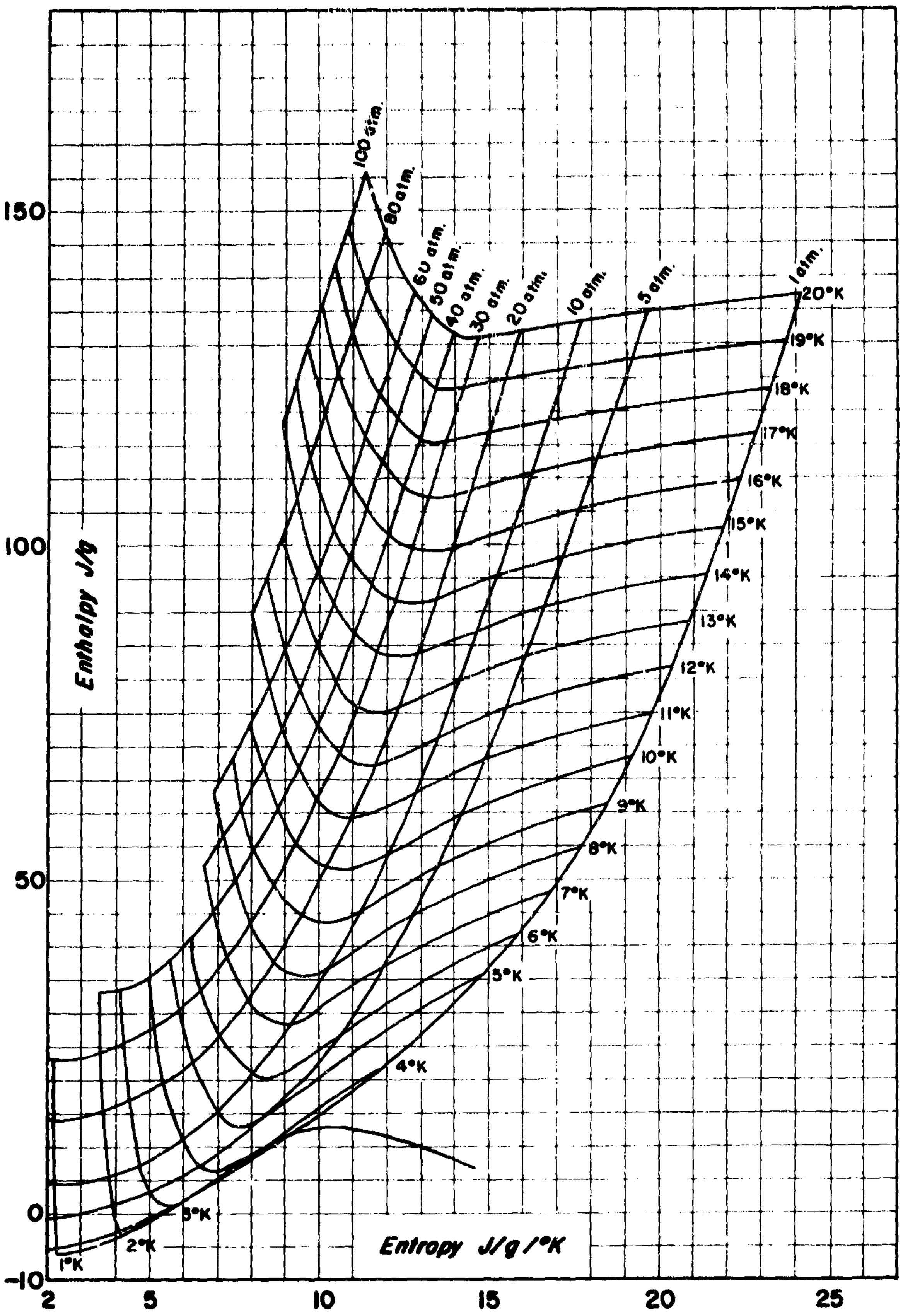
TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM /SEC/ DEG.X100000
9.000	7.510	98.904	22.797	7.259		49.975
10.000	7.649	102.446	25.037	7.542		50.646
11.000	7.781	106.565	27.718	7.869		51.233
12.000	7.933	111.249	30.870	8.213		51.748
13.000	8.097	116.453	34.471	8.593	59.459	52.200
14.000	8.267	122.216	38.475	8.989	60.328	52.614
15.000	8.443	128.422	42.818	9.394	60.369	52.994
16.000	8.633	134.880	47.431	9.806	59.818	53.327
17.000	8.826	141.680	52.265	10.214	59.082	53.644
18.000	9.025	148.711	57.267	10.616	58.346	53.942
19.000	9.227	155.953	62.394	11.008	57.731	54.232
20.000	9.439	163.258	67.604	11.392	57.222	54.499
21.000	9.707	171.796	73.433	12.363	56.566	54.634
22.000	9.934	177.815	77.160	12.655	56.302	54.879
23.000	10.166	183.924	80.919	12.[illegible]	56.125	55.117
24.000	10.403	190.120	84.713	13.212	56.015	55.350
25.000	10.641	196.435	88.540	13.475	55.973	55.590
26.000	10.889	202.781	92.401	13.734	55.950	55.817
27.000	11.141	209.210	96.296	13.986	55.964	56.045
28.000	11.397	215.714	100.222	14.230	56.011	56.276
29.000	11.655	222.287	104.178	14.467	56.087	56.509
30.000	11.917	228.922	108.162	14.698	56.192	56.746
31.000	12.182	235.615	112.172	14.922	56.323	56.987
32.000	12.450	242.359	116.207	15.141	56.481	57.233
33.000	12.720	249.149	120.263	15.355	56.667	57.483
34.000	12.992	255.982	124.340	15.562	56.878	57.739
35.000	13.266	262.853	128.435	15.765	57.115	58.000
36.000	13.542	269.757	132.546	15.963	57.378	58.267
37.000	13.812	276.720	136.668	16.154	57.676	58.550
38.000	14.091	283.675	140.809	16.342	57.983	58.826
39.000	14.372	290.656	144.961	16.526	58.311	59.108

P=100.00ATM.

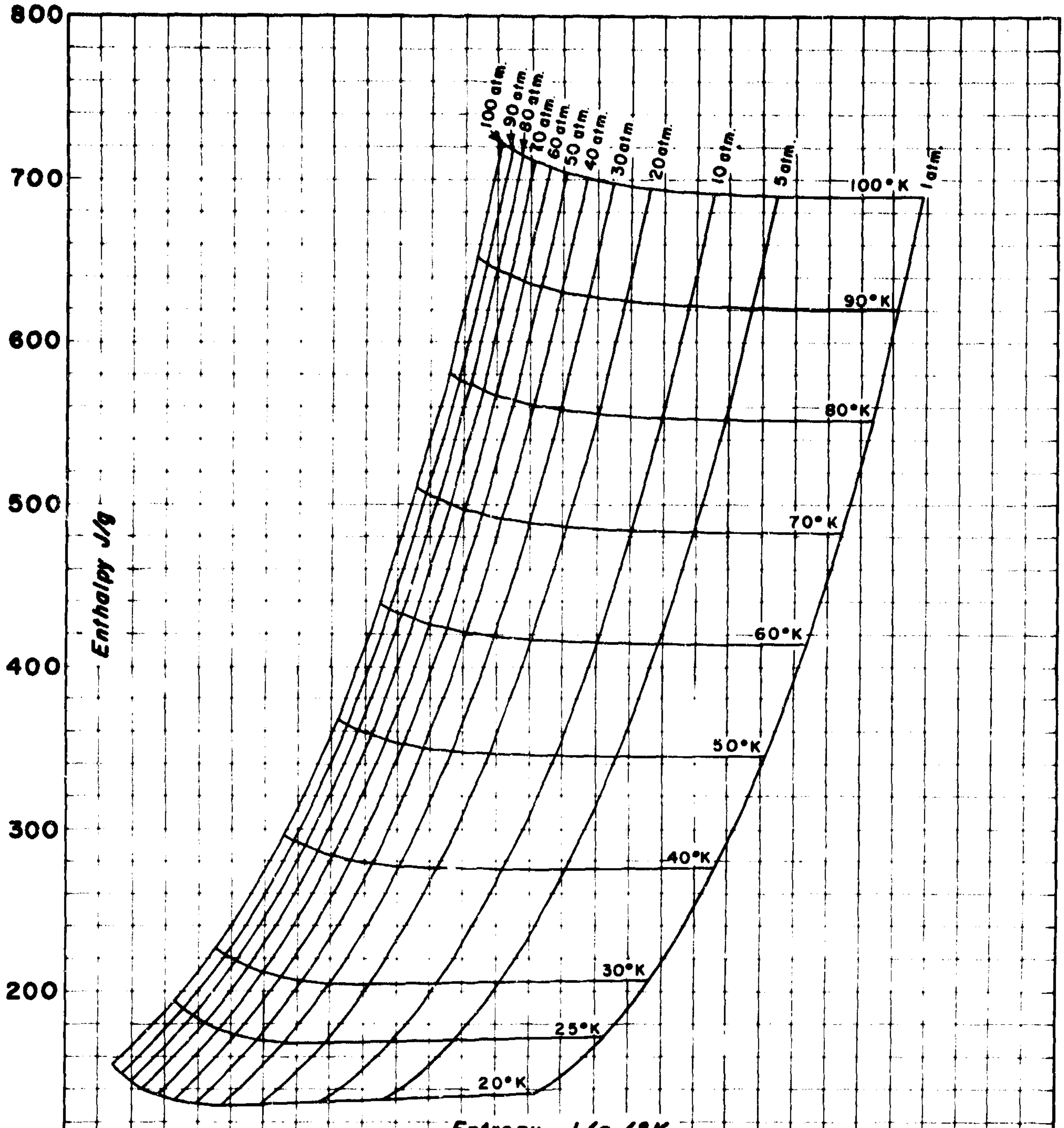
TEMP. DEG.K	VOL. C.C./G.	ENTHALPY J./G	INTERNAL ENERGY J./G.	ENTROPY J./G./ DEG.K	VISCOSITY μPOISES	TH.COND J./CM./SEC/ DEG.X100000
40.000	14.606	296.569	148.518	16.576	58.764	59.454
42.000	15.172	310.694	156.923	16.925	59.522	60.042
44.000	15.741	324.869	165.352	17.258	60.344	60.653
46.000	16.310	339.082	173.799	17.577	61.220	61.283
48.000	16.881	353.321	182.260	17.882	62.141	61.932
50.000	17.453	367.577	190.729	18.175	63.100	62.598
52.000	18.024	381.844	199.205	18.456	64.089	63.279
54.000	18.596	396.117	207.684	18.727	65.105	63.975
56.000	19.168	410.391	216.165	18.988	66.143	64.682
58.000	19.740	424.663	224.645	19.239	67.199	65.401
60.000	20.311	438.931	233.125	19.482	68.269	66.130
62.000	20.882	453.193	241.602	19.716	69.352	66.867
64.000	21.453	467.448	250.077	19.943	70.445	67.613
66.000	22.023	481.694	258.549	20.163	71.546	68.365
68.000	22.592	495.930	267.016	20.376	72.654	69.123
70.000	23.161	510.157	275.480	20.582	73.766	69.886
72.000	23.729	524.375	283.940	20.783	74.882	70.654
74.000	24.297	538.582	292.396	20.978	76.000	71.426
76.000	24.864	552.779	300.847	21.167	77.120	72.201
78.000	25.430	566.966	309.293	21.352	78.241	72.978
80.000	25.996	581.143	317.736	21.532	79.362	73.758
82.000	26.562	595.310	326.175	21.707	80.482	74.540
84.000	27.126	609.467	334.609	21.877	81.601	75.323
86.000	27.691	623.615	343.039	22.044	82.719	76.107
88.000	28.254	637.753	351.465	22.207	83.835	76.891
90.000	28.818	651.882	359.887	22.366	84.949	77.676
92.000	29.380	666.002	368.306	22.521	86.060	78.461
94.000	29.943	680.114	376.720	22.673	87.170	79.246
96.000	30.484	694.247	385.123	22.819	88.281	80.037
98.000	31.046	708.340	393.531	22.965	89.385	80.820
100.000	31.608	722.426	401.936	23.107	90.486	81.602

APPENDIX III

MOLLIER CHART FOR He^3 FROM 1^oK TO 20^oK
MOLLIER CHART FOR He^3 FROM 20^oK TO 100^oK



APPENDIX III. **Mollier chart for He^3 from 1° K to 20° K**



APPENDIX III. Mollier chart for He^3 from 20° K to 100° K

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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D. I. Nathan

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13. ABSTRACT

The PVT properties, entropy, enthalpy, internal energy, thermal conductivity and viscosity of He^3 have been tabulated between 1°K and 100°K at selected pressures up to 100 atm. Measurements were made on the PVT properties and the specific heat at constant volume of gaseous He^3 from 4°K to 20°K and a modified Strobridge equation was obtained which represented the PVT data within ±1%. Using this equation, the SVT and HVT surfaces were obtained from 4°K to 20°K. A correlation based on the quantum version of the principle of corresponding states was used to calculate the thermodynamic properties of He^3 from 20°K to 100°K. Similar correlations were developed for the viscosity and thermal conductivity of He^3 for temperatures up to 100°K. Tabulations of thermodynamic properties of He^3 along the vapor-liquid boundary and in the compressed liquid region are also included in the tables. An H-S diagram of the data with P, V, and T as parameters is included in the report.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

Unclassified
Security Classification

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
He^3 Thermodynamic and transport properties Specific heat of He^3 Experimental PVT data						

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